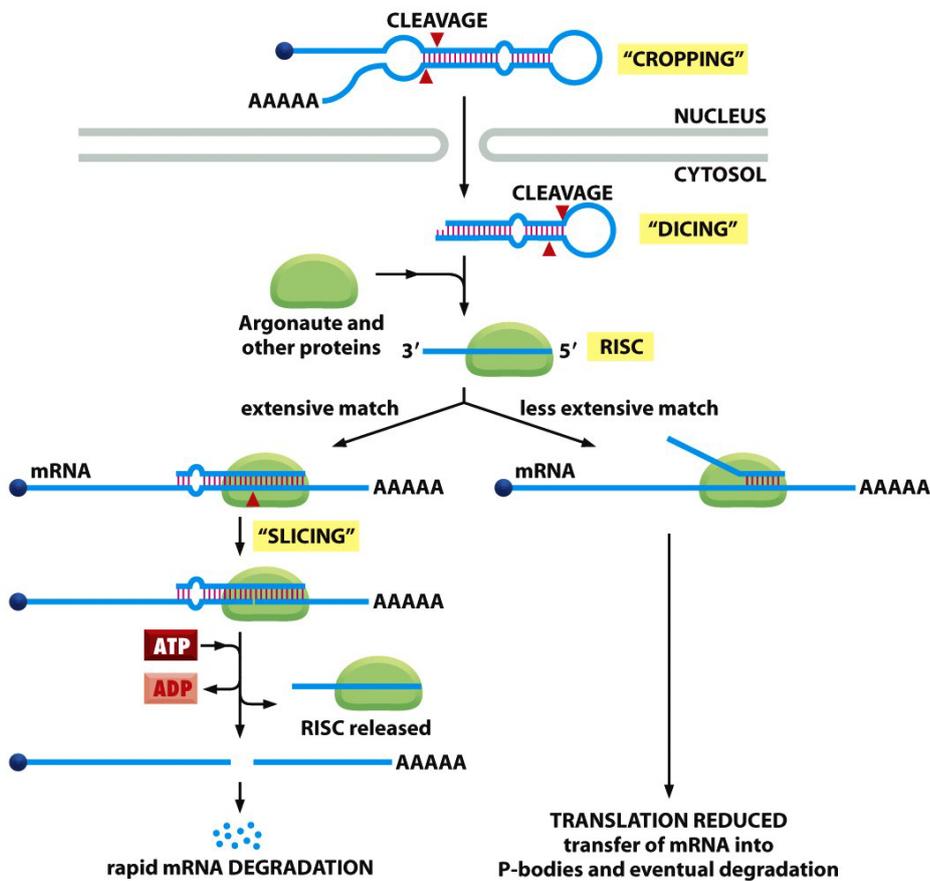


## REASONING AND CRITICAL THINKING IN PRE-MEDICAL SCIENCES 2021

## BIOLOGY

The following information refers to questions no. 1-5.



One of the types of RNAs found in the cell is microRNA (miRNA). It is a short, single-stranded, noncoding molecule. The miRNA precursor is synthesized by RNA polymerase II and following the transcription, it is capped and polyadenylated. Through complementarity (A-U, C-G) between one part of its sequence and another, it forms a double-stranded structure. While still in the nucleus, it is cropped and then exported to the cytosol where it is further cleaved by the Dicer enzyme. Then, miRNA is assembled with a set of proteins to form an RNA-induced silencing complex (RISC). The protein components of RISC initially associate with both strands of the miRNA and then cleave and discard one of them. The other strand guides RISC to specific mRNAs through base pairing. This search is greatly facilitated by the Argonaute protein, a component of RISC, which displays the 5' region of the miRNA so that it is optimally positioned for base pairing to the mRNA molecule. In animals, the extent of base pairing is typically seven nucleotide pairs and it usually takes place in the 3'UTR of the target mRNA. This less extensive base pairing leads to inhibition of translation, mRNA destabilization, and transfer of the mRNA to P-bodies, where it is eventually degraded. If the base pairing is extensive, the mRNA is cleaved by the Argonaute protein, effectively removing its poly-A tail and exposing it to exonucleases. Following cleavage of the mRNA, RISC (with its associated miRNA) is released, and it can seek out additional mRNAs. The miRNAs can be thought of as guide sequences that bring destructive nucleases into contact with specific mRNAs.

- Based on the information above, indicate which of the following statements is true:
  - In animal cells, the miRNA molecules are seven nucleotides long.
  - Dicer enzyme makes miRNA single-stranded by cleaving and discarding one of its two strands.
  - miRNAs cause gene silencing by inhibiting the process of transcription.
  - One particular miRNA molecule can bind to more than just one specific mRNA fragment.
  - Since miRNAs regulate gene expression, they always bind to protein-coding regions.
- Which of the following is a component of the RISC:
  - Dicer
  - mRNA
  - ATP
  - Argonaute
  - Exonuclease
- What conclusion regarding poly-A-tail can be drawn from the text?
  - It is a sequence specific only to miRNA.
  - It protects the mRNA molecule from enzymatic degradation in the cytoplasm.
  - It is added to mRNA by the RNA polymerase III.
  - It is a form of post-translational modification.
  - It is synthesized in the cytoplasm.
- Given the sequence of miRNA fragment, decide to which part of the mRNA it will most likely bind:

miRNA – 5'-UCGGCAUG-3'

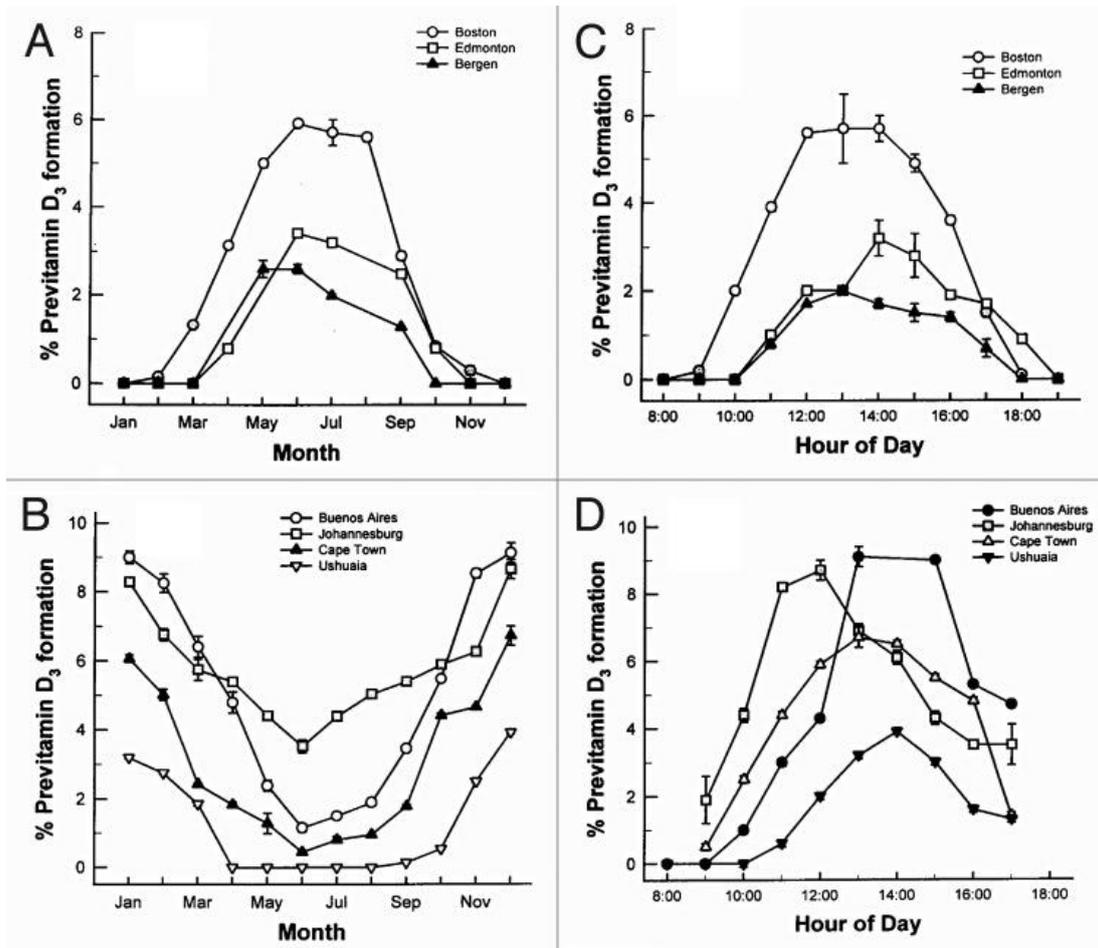
mRNA- 5'- **CCGUGGCA** **CACGGAAU** **AGCCACGC** **AGCCGUAC** **CAUGCCGA** -3'

I                      II                      III                      IV                      V

- I
  - II
  - III
  - IV
  - V
- Which of the following processes is **not** a type of post-transcriptional modification of mRNA:
    - capping
    - polyadenylation
    - folding
    - splicing
    - None of the above
  - Elastase is an endopeptidase which cuts peptide chains mainly at the carboxyl side of small hydrophobic amino acids such as glycine, alanine, and valine. If the following peptide was treated with elastase, how many fragments would be obtained?
 

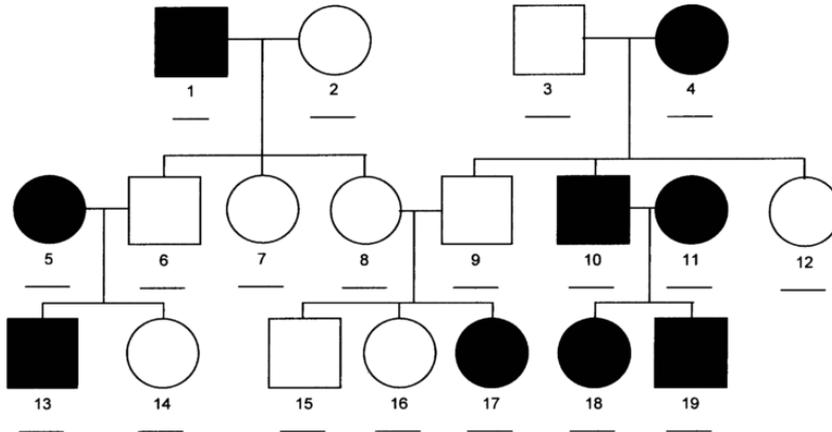
Met-Glu-Ala-Lys-Leu-Gly-Glu-Arg-Cys-Met-Trp-Val-Glu-Cys-Ser-Arg-Phe-Ala

    - 4
    - 5
    - 3
    - 6
    - 2



**Figure 1.** Influence of season, time of day, and latitude on the synthesis of previtamin D<sub>3</sub> in northern (A and C) and southern hemispheres (B and D). The hour indicated in C and D is the end of the 1 h exposure time. Holick, copyright 1998.

7. Based on the figure presented above, which of the following statements considering previtamin D<sub>3</sub> formation is **FALSE**:
  - A. For all the countries on the southern hemisphere, it is highest in December.
  - B. For all the countries on the northern hemisphere, it is highest in June.
  - C. It is the same for two countries in October.
  - D. There are three countries in which it equals zero during some months.
  - E. It reaches higher values in the southern countries than in the northern countries.
8. A study followed a family with multiple cases of Oguchi disease. It is a rare form of congenital stationary night blindness associated with slow dark adaptation and eye fundus discoloration. Based on the pedigree presented below, what type of Mendelian inheritance does the Oguchi disease most likely exhibit?



**Figure 2.** Key: Circles are female, squares are male, black-filled shapes indicate individuals with Oguchi disease.

- A. Autosomal dominant
- B. Autosomal recessive
- C. Y-linked
- D. X-linked dominant
- E. X-linked recessive

The following information refers to questions no. 9 and 10.

DNA molecules are very long chains, so in order to fit within the nucleus they are wrapped around “packaging” proteins called histones. In the interphase, histones with wrapped DNA are visible in the electron microscope as distinct units called nucleosomes

9. Histones allow for:
- A. Mixing of genetic information between and among gene segments.
  - B. Enzyme synthesis within the nucleus.
  - C. Packaging of DNA in the nucleus.
  - D. “Packaging” protein synthesis in the nucleosomes.
  - E. Efficient packaging of the nucleolus.
10. Nucleosomes refer to:
- A. Structural units of the nucleotide bases.
  - B. Structural units of DNA/histone complex.
  - C. Functional subunits of histones.
  - D. Functional units of the nucleolus.
  - E. Structural units of the nuclear envelope.

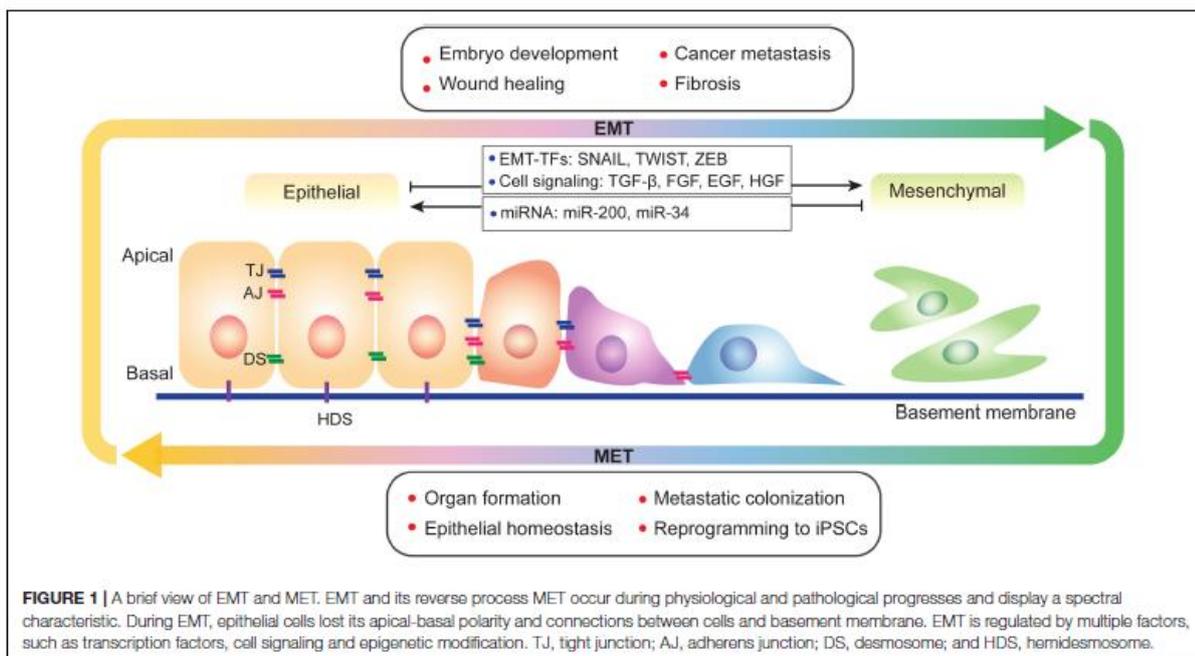
The following information refers to questions no. 11 and 12.

The grey matter of the cerebral cortex contains neuronal cell bodies which are responsible for the highest intellectual functions, integration, and interpretation of various sensory signals. The hypothalamus, situated on the underside of the brain, maintains homeostasis through hormonal regulation. Posterior to the hypothalamus is the thalamus. It relays information between the spinal cord and the cerebral cortex. The pons connects the spinal cord and medulla with the upper regions of the brain. The cerebellum controls posture, muscle tone, and spatial equilibrium. Between the pons and the spinal cord lays the

medulla, which regulates involuntary processes such as heart rate, respiration, blood pressure, and reflex reactions.

11. Which part of the human brain controls the appetite and body temperature?
- Cerebrum
  - Medulla
  - Hypothalamus
  - Cerebellum
  - Pons
12. A patient exhibiting the loss of abstract thinking ability most likely has a lesion affecting the:
- Cerebellum
  - Cerebral cortex
  - Thalamus
  - Hypothalamus
  - Medulla

The following information refers to questions no. 13 and 14.



Lai X, Li Q, Wu F, Lin J, Chen J, Zheng H and Guo L (2020) *Epithelial-Mesenchymal Transition and Metabolic Switching in Cancer: Lessons From Somatic Cell Reprogramming*. *Front. Cell Dev. Biol.* 8:760. doi: 10.3389/fcell.2020.00760

Epithelial-mesenchymal transition (EMT) is defined as a biological process in which epithelial cells lose their characteristics and acquire mesenchymal features. During EMT, epithelial cells lose cell-cell junctions, apical-basal polarity, and epithelial markers, and acquire cell motility, a spindle-cell shape, and mesenchymal markers. [...] EMT and its reverse process mesenchymal-epithelial transition (MET) display fundamental principles in diversified physiological and pathological progresses. During metazoan development, cells may sequentially undergo rounds of EMT and MET, as is seen in somite formation and heart development. EMT also occurs during wound healing in adults. [...] EMT also plays important roles in

cancer progression and tissue fibrosis (Nieto et al., 2016; Pastushenko and Blanpain, 2019; Williams et al., 2019). Interestingly, during the processes of embryonic stem cells (ESCs) differentiation and induced pluripotent stem cells (iPSCs) formation, EMT and MET are highly relevant to the loss and acquisition of pluripotency (Peiet al., 2019). EMT and MET are widely involved in various biological scenarios, and display highly plastic and dynamic manners during cell fate transitions (Figure 1). Epithelial-mesenchymal transition is regulated at different levels by multiple factors, including cell signaling, transcriptional control, epigenetic modification, and post-translational modifications (Figure 1).

13. Which of the following is not a type of cell to cell junction:

- A. Desmosome
- B. Hemidesmosome
- C. Adherens junction
- D. Tight junction
- E. Gap junction

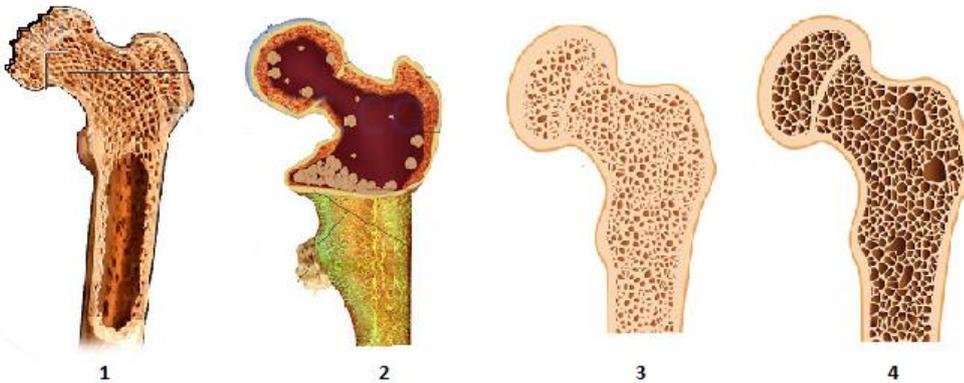
14. What is true about the iPSCs:

- A. They are involved in the embryonic development.
- B. They might result from the process of MET.
- C. They are involved in cancer metastasis.
- D. They might result from the process of EMT.
- E. They are involved in the process of wound healing.

**The following information refers to questions no. 15 to 17.**

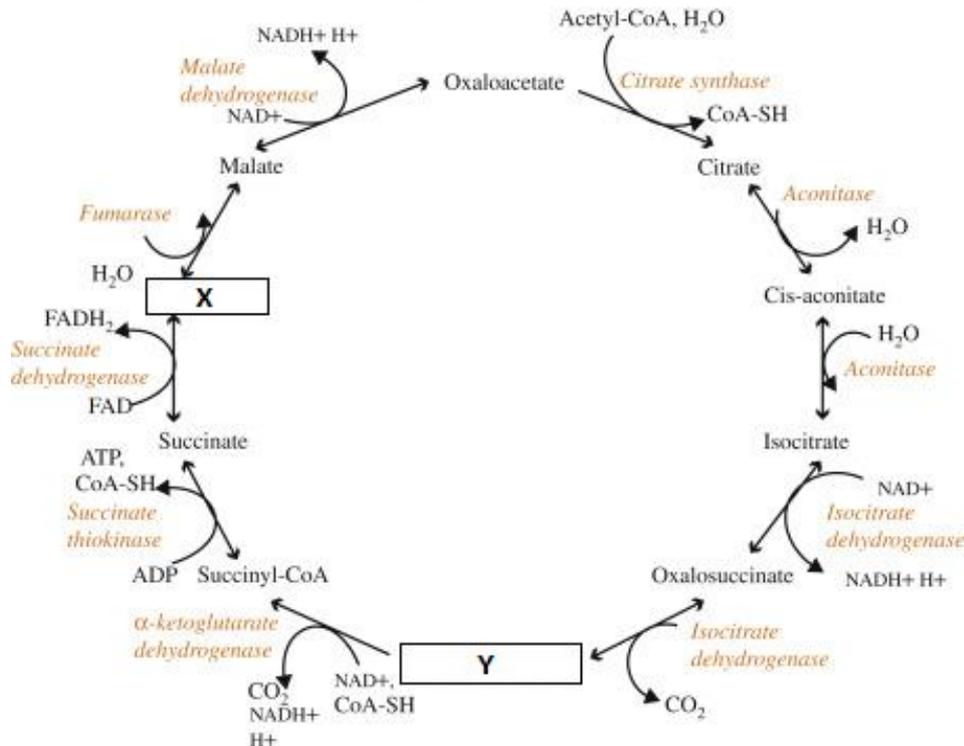
Bone is a dynamic organ composed of cells, matrix, and minerals. A healthy bone is made of osteoblasts, osteoclasts, osteocytes, and matrix. In humans, normal bone repair begins when the osteoclasts resorb old bone to create space for the new one. Meanwhile, the osteoblasts lay down a new bone in that area. The simultaneous occurrence of these processes allows the bone to maintain its strength. With age, however, bone modelling may be disrupted. Dissolved bone can be diverted to the serum, as a result of which bone loss exceeds bone replacement. The new bone created this way is prone to fracture. Osteoporosis results from reduced bone mass (osteopenia) while the bone matrix remains normally mineralized. Optimal serum levels of calcium are crucial to maintaining a healthy bone. Under-absorption of calcium by the gastrointestinal tract (GI) leads to reduced bone mass. Low levels of serum calcium activate a biofeedback system involving calcium, vitamin D, and parathyroid hormone. The activated system causes bone destruction in order to release calcium into the bloodstream. Hyperparathyroidism, renal failure, and vitamin D deficiency also affect bones negatively. Drugs implicated in the development of osteoporosis include corticosteroids, which reduce bone mass, and phenytoin, which alters the vitamin D metabolism in the liver. Another factor that affects bone turnover is Paget's disease. In pagetic bone, the processes of resorption and formation are accelerated and result in dense and chaotic structure. Pagetic bone bears little structural resemblance to the honey-comb appearance of a healthy one. However, the image is different from osteonecrosis where a whole section of the bone is clearly destroyed and missing. Moreover, in pagetic bone, osteoclasts contain fifty to one hundred nuclei per cell, while in a healthy bone there are four to ten. These osteoclasts are also bigger and more numerous than in a healthy bone.

15. Which of the following statements (I to III) is/are true about the osteoclasts?
- They are multinucleated cells.
  - They are a type of bone cell.
  - They deposit new bone during bone remodeling.
- II only
  - I and II
  - I, II and III
  - II and III
  - I and III
16. Which of the following is a pathophysiological process associated with osteopenia?
- Decreased rate of bone resorption.
  - Decreased gastrointestinal absorption of calcium.
  - Increased production of osteoblasts.
  - Increased rate of bone formation.
  - Increased gastrointestinal absorption of calcium.
17. Look at the pictures below. Which descriptions properly match the bones?



- 1- bone cancer, 2- osteoporosis, 3- healthy bone, 4- osteonecrosis
  - 1- pagetic bone, 2- osteonecrosis, 3- osteoporosis, 4- healthy bone
  - 1- osteonecrosis, 2-pagetic bone, 3 – healthy bone, 4- bone cancer
  - 1- osteonecrosis, 2- bone cancer, 3- healthy bone, 4- osteoporosis
  - 1- osteonecrosis, 2- healthy bone, 3-pagetic bone, 4-bone cancer
18. The name of an enzyme is often derived from the name of its substrate or the chemical reaction which it catalyzes, with an *-ase* at the end. Different types of enzymes catalyze different reactions, for example:
- Oxidoreductases: catalyze oxidation/reduction reactions (also commonly named as “*donor*”-dehydrogenase or “*acceptor*”-reductase)
  - Transferases: transfer a functional group (e.g. a methyl or phosphate group)
    - Kinases: catalyze the transfer of phosphate groups from high-energy, phosphate-donating molecules to specific substrates
  - Hydrolases: catalyze the hydrolysis of various bonds
  - Isomerases: catalyze isomerization changes within a single molecule

What are the names of the missing substrates (X and Y)?



- A. X- Fumarate, Y- Alpha- ketoglutarate
- B. X- Phosphofumarate, Y- Isocitrate
- C. X- Fumarate, Y- Ketoglutarase
- D. X- Phosphofumarate, Y- Alpha- ketoglutarate
- E. X- Fumaryl, Y- Isocitrate

The following information refers to question no. 19:

*Bordetella pertussis*, the bacterium that causes whooping cough, is a remarkable example of active colonization. The first step in a *B. pertussis* infection is colonization of the respiratory epithelium. The bacteria circumvent the normal clearance mechanism that clears the respiratory tract [...] by binding tightly to the surface of the ciliated cells that line the tract, and multiplying on them. *B. pertussis* expresses at least four adhesins that bind tightly to particular glycolipids on the ciliated cells. The adherent bacteria produce various toxins that eventually kill the ciliated cells, compromising the host's ability to clear the infection. (Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Garland Science, 2007)

19. Which of the statements is true?

- A. *B. pertussis* permanently impairs the clearance mechanism of the respiratory tract.
- B. *B. pertussis* binds to the adhesins of the ciliated cells.
- C. The toxins produced by *B. pertussis* block the glycolipids of the ciliated cells.
- D. The increased ciliary movement of ciliated cells causes a spread of bacteria.
- E. The lack of ciliary movement of ciliated cells causes a coughing fit.

20. The lens is a transparent structure which focuses light rays on the retina. Myopia occurs when the lens focuses light from a distant object in front of retina. Hyperopia occurs when light from a nearby object is focused behind the retina.

Which of the statements is true?

- A. The eyeball of a person with myopia is too short.
  - B. The eyeball of a person with hyperopia is too long.
  - C. The eyeball of a person with myopia is the same length as of a healthy person.
  - D. The eyeball of a person with myopia is too long.
  - E. The length of the eyeball is irrelevant to hyperopia.
21. When using antipyretics in paediatric patients, the dose should be adjusted according to the child's weight. In the case of ibuprofen, if the child's temperature does not exceed 39°C, a single dose of 5 mg / kg body weight is recommended, and if the fever exceeds 39°C, the recommended single dose is 10 mg / kg body weight. In both cases, the maximum daily dose should not exceed 20-30 mg / kg body weight. The drug may be administered every 6 to 8 hours.

What would be a single dose of ibuprofen at a concentration of 40 mg /ml that should be given to a 14 kg child who has a fever of 38.5°C?

- A. 3.5 ml
- B. 1500 µl
- C. 0.75 ml
- D. 175 µl
- E. 1.75 ml

**The following information refers to questions no. 22 and 23.**

Ultrasound is a sound of a frequency higher than 20 kHz (which is above the human hearing range). It is commonly used in medicine for sonography. In sonography, ultrasonic waves are sent through the body, and the reflected waves that bounce off from different tissues are measured and translated by a computer into a visual image. Various tissues have characteristic attenuation coefficients (**Table 1**) which illustrate how quickly the beam is attenuated as it passes through them. The lower the coefficient, the more transparent this particular medium is to the beam.

**Table 1.** Attenuation coefficients of sound in various bodily tissues

Substance	Attenuation coefficient [dB / (MHz x cm)]
Air	1.64
Blood	0.2
Cortical Bone	6.9
Brain	0.6
Cardiac	0.52
Enamel	120

(Source: Culjat, Martin O.; Goldenberg, David; Tewari, Priyamvada; Singh, Rahul S. (2010). A Review of Tissue Substitutes for Ultrasound Imaging. *Ultrasound in Medicine & Biology* 36 (6): 861–873.)

22. If a sonography machine emits a sound wave of 900 kHz into a soft tissue, what would be the size of the wavelength, given that the speed of sound in a soft tissue is 1540 m/s? (wave equation –  $v = \lambda f$ )
- A. 0.0171 m
  - B. 0.171 m
  - C. 17.1 mm
  - D. 1.71mm
  - E.  $1.71 \times 10^{-4}$  m
23. Considering the data provided in **Table 1**, which of the statements is true?
- A. The brain is more transparent to the ultrasound wave than the blood.
  - B. The attenuation of the beam is greater in bone than in the brain.
  - C. The ultrasound wave is weakened by the enamel less than by the bone.
  - D. The air does not cause any attenuation of the beam.
  - E. The attenuation coefficient of the cardiac tissue is 63% lower than the one of the enamel.

**The following information refers to questions no. 24-28.**

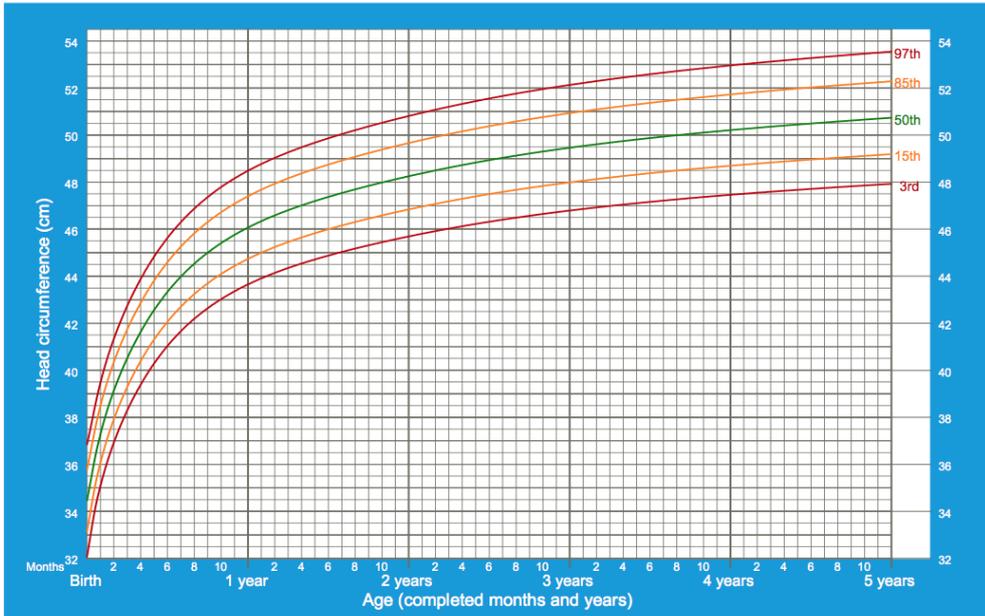
Growth charts are widely used by paediatricians and child development experts to track and compare a child's height and weight against the World Health Organization standards for babies and children. Several curves run through the grid. The 97th percentile line is the highest. It means that 97% of children from a given population have a lower value. The 50th percentile means that in half of the children from a given population the parameter is lower and in the other half. The area between the 3<sup>rd</sup> and the 97<sup>th</sup> percentiles is considered to be the norm, but it is important that the child's development curve remains in approximately the same percentile, and that the proportions of percentile values for different parameters are relatively constant.

Based on the given information, indicate whether the statements are true (T) or false (F) :

- 24. 50% of boys at six months are about 68cm in length. T/F
- 25. A boy whose head circumference at the age of 1 was 47.5cm should preferably have the same parameter equal to about 51cm at the age of 3. T/F
- 26. The length of 81cm at the age of 1 for a boy is considered to be within the norm. T/F
- 27. The head circumference of 47.5cm for a 3.5-year-old boy is considered to be within the norm. T/F
- 28. 15% of 7-month-old baby boys are shorter than 67cm in length. T/F

## Head circumference-for-age BOYS

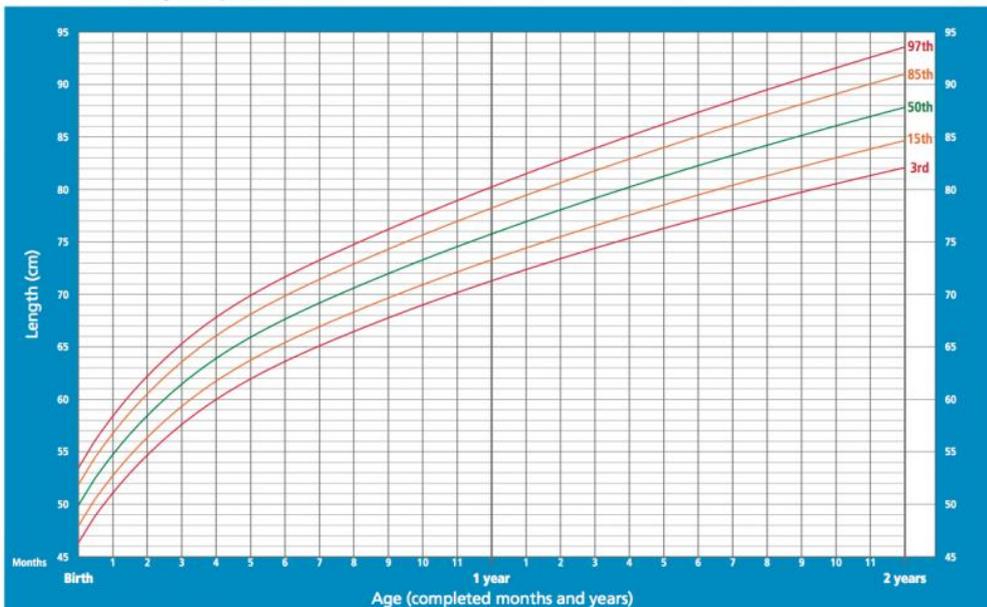
Birth to 5 years (percentiles)



WHO Child Growth Standards

## Length-for-age BOYS

Birth to 2 years (percentiles)



WHO Child Growth Standards

29. In a more serious form of periodontal disease (also called periodontitis), the gums can pull away from the teeth, bone loss can occur, and the teeth may loosen and eventually fall out. Bad breath may also occur.

X – In periodontitis, bone and teeth are lost due to gum recession.

Y – Bad breath is one of the symptoms of periodontitis.

Based on this information it can be said that:

- A. X is true but Y is false.
- B. X is false but Y is true.
- C. Both X and Y are true.
- D. Both X and Y are true and X explains Y.
- E. Both X and Y are false.

The following information refers to questions no. **30-34**.

From: Heike Rebholz et al. **Loss of Olfactory Function-Early Indicator for Covid-19, Other Viral Infections and Neurodegenerative Disorders.** *Front Neurol.* 2020 Oct 26;11:569333.

The loss of the senses of smell (anosmia) and taste (ageusia) are rather common disorders, affecting up to 20% of the adult population. Yet, this condition has not received the attention it deserves, most probably because per se such a disorder is not life-threatening. However, loss of olfactory function significantly reduces the quality of life of the affected patients, leading to dislike in food and insufficient, exaggerated, or unbalanced food intake, unintentional exposure to toxins such as household gas, social isolation, depression, and overall insecurity. Not only is olfactory dysfunction rather prevalent in the healthy population, it is, in many instances, also a correlate or an early indicator of a panoply of diseases. Importantly, olfactory dysfunction is linked to the two most prominent neurodegenerative disorders, Parkinson's disease and Alzheimer's disease. Anosmia and hyposmia (reduced sense of smell) affect a majority of patients years before the onset of cognitive or motor symptoms, establishing olfactory dysfunction as an early biomarker that can enable earlier diagnosis and preventative treatments. In the current health crisis caused by SARS-CoV2, anosmia and dysgeusia (changed sense of taste) as early-onset symptoms in virus-positive patients may prove to be highly relevant and crucial for pre-symptomatic Covid-19 detection from a public health perspective, preceding by days the more classical respiratory tract symptoms such as cough, tightness of the chest or fever. Thus, the olfactory system seems to be at the frontline of pathologic assault, be it through pathogens or insults that can lead to or at least associate with neurodegeneration. The aim of this review is to assemble current knowledge from different medical fields that all share a common denominator, olfactory/gustatory dysfunction, and to distill overarching etiologies and disease progression mechanisms.

30. Which statement is true?

- A. Anosmia may affect up to 20% of the adult population.
- B. Olfactory dysfunction is common in patients with Alzheimer's disease.
- C. Dysgeusia is an early-onset symptom of COVID-19.
- D. Parkinson's disease is a neurodegenerative disease.
- E. All answers are true

31. Which statement is NOT true?

- A. Dysgeusia is a classical symptom of COVID-19.
- B. Reduced sense of smell may precede by many years the onset of cognitive problems in patients with Alzheimer's disease.
- C. Hyposmia may precede by days the onset of cough and fever in COVID-19 patients.
- D. Loss of olfactory function is associated with greater risk of malnutrition in older people.
- E. The olfactory dysfunction may precede by many years the onset of motor symptoms in patients with Parkinson's disease.

32. The Authors suggest that:

- A. olfactory/gustatory dysfunctions represent an interdisciplinary problem in medicine.
- B. olfactory/gustatory dysfunctions are involved in many health and social problems of older people.
- C. there is a causal relationship between loss of olfactory function and neurodegeneration.
- D. Answers A and B are correct
- E. Answers A, B, and C are correct

33. Which statement is true?

- A. Patients with Alzheimer's disease and Parkinson's disease share neurodegeneration as a common pathophysiological background.
- B. There is a causal relationship between presence of Alzheimer's disease and incidence of COVID-19.
- C. Up to 20% of adult population is endangered by development of neurodegenerative diseases.
- D. The authors suggest that a patients' hyposmia may increase their susceptibility to COVID-19.
- E. All answers are correct

34. Which statement is NOT true?

- A. Dysgeusia may be useful in COVID-19 diagnosis in the early, pre-symptomatic period of infection.
- B. The authors suggest that COVID-19 will increase the risk of development of neurodegenerative diseases.
- C. Due to COVID-19 pandemic, olfactory dysfunction received more meritorious medical attention.
- D. The authors suggest that the olfactory system is one of the first affected in COVID-19.
- E. The authors suggest that many patients with Parkinson's disease may have problems with balanced food intake.

35. Plasma makes up to 55% of the blood. The cellular compartment in 5 litres of blood amounts c.a. to:
- A. 2250 ml
  - B. 2500 ml
  - C. 3000 ml
  - D. 1520 ml
  - E. 1250 ml
36. Deadly nerve agents are odorless, oily liquids (1 drop weighs c.a. 30 mg). The lethal dose of the deadly nerve chemical **sarin** is 20 mg/kg. Another toxic nerve agent – **VX**- is 100 times more potent. The lethal dose of VX for a 70 kg adult man amounts to:
- A. 2 mg
  - B. 14 mg
  - C. 50 mg
  - D. 140 mg
  - E. 1.4 mg

**The following information refers to questions no. 37 - 39.**

From: Srivastava N, Pande M. **Mitochondrion: Features, functions and comparative analysis of specific probes in detecting sperm cell damages.** *Asian Pacific J of Reprod.* 2016, 5(6), 445-452

Reactive species (*e.g.* reactive oxygen species, superoxide anion, hydroxyl radical, hydroperoxyl radical, and reactive nitrogen species, nitric oxide, nitrogen dioxide, nitronium cation) are continuously generated in normal cellular processes and are essential to life. However, when the homeostasis of reactive species is disturbed (overproduced, or when antioxidants are depleted), these free radicals cause oxidative stress, leading to irreversible cellular damages. (...) Mitochondria are cellular organelles that play a key role in maintaining the cellular bio-energetic- and ion-homeostasis and are producers of reactive species. At the same time, it also plays a central role in the regulation of apoptosis (programmed cell death). Similar to 'Janus', the mitochondrion presents two faces looking both forward and backwards. On the one hand, it is involved in the maintenance of viability and vitality; on the other hand, it plays a central role in the regulation of programmed cell death. Thus, the mitochondrion may be considered the guardian of the gate between life and death) (...)

37. Which statement is true?

- A. The excess of reactive oxygen species is deleterious to cells.
- B. Mitochondria play a role in cellular ion-homeostasis.
- C. Mitochondria play a central role in maintaining the cell viability.
- D. Answers A and B are correct
- E. All answers are correct

38. Which statement is NOT true?

- A. Nitric oxide is an example of reactive nitrogen species.
- B. Reactive oxygen species play a physiological role in cells.
- C. Mitochondria do not produce nitric oxide.
- D. Mitochondrial dysfunction may contribute to cell apoptosis.
- E. Mitochondria do not produce oxygen.

39. The authors suggest that:

- A. Proper function of mitochondria requires sufficient production of cellular antioxidants.
- B. The amount of reactive oxygen/nitrogen species will rise if the metabolic activity of the cell is decreased (e.g. in low temperature).
- C. Mitochondria are responsible for production of antioxidants.
- D. The cellular ion-homeostasis is not related to the function of mitochondria.
- E. None of above answers is true.

40. The size of haploid genome of budding yeast is c.a. 1.2 million base pairs (bp) and estimated number of genes amounts to 6300. How many genes is found in human genome (haploid size: 3.2 billion bp)?

- A. c.a. 12 million
- B. c.a. 7 million
- C. c.a. 0.7 million
- D. c.a. 24 million
- E. Due to differences in the genome structure between humans and yeasts, the data provided is insufficient to make the calculation and answer the question.

41. A mole is X grams of a substance, where X is its relative molecular mass (molecular weight). Molar solutions have a concentration of 1 mole of the substance in 1 litre of solution. 1 mole of sodium chloride weighs 58 grams (g). How much sodium chloride should be dissolved in 100 ml of water to prepare 0.3 molar solution (0.3 M)?
- A. 3.48 g
  - B. 17.4 g
  - C. 1.74 g
  - D. 34.8 g
  - E. None of above answers is true
42. A kilocalorie (kcal) is the amount of energy needed to raise the temperature of one litre of water by one degree Celsius (centigrade). A widely used equivalent measure of energy is the kilojoule, which is equal to 0.239 kilocalories. Basal metabolic rate (BMR) is the total number of calories that your body needs to perform the basic, life-sustaining functions. BMR of a 20-year-old, moderately active man (80 kg weight, 180 cm height) is c.a. 10000 kilojoules, which amounts to:
- A. 1390 kcal
  - B. 2390 kcal
  - C. 42000 kcal
  - D. 1890 kcal
  - E. None of the above answers is correct

**The following information refers to questions no. 43 - 45**

From: Brand HS, ECI. **Saliva and wound healing.** *Chin J Dent Res.* 2013;16(1):7-12.

Wounds in the oral cavity heal faster and with less scarring than wounds in other parts of the body. One of the factors implicated in this phenomenon is the presence of saliva, which promotes the healing of oral wounds in several ways. Saliva creates a humid environment, which improves the survival and functioning of inflammatory cells that are crucial for wound healing. Furthermore, saliva contains a variety of proteins that play a role in the various stages of intraoral wound healing. Tissue factor present in salivary exosomes accelerates the clotting of blood dramatically. The subsequent proliferation of epithelial cells is promoted by growth factors in saliva, especially epidermal growth factor. The importance of secretory leucocyte protease inhibitor is demonstrated by the observation that in the absence of this salivary protein, oral wound healing is considerably delayed. Members of the salivary histatin family promote wound closure in vitro by enhancing cell spreading and cell migration. Cell proliferation is not enhanced by histatin. Cyclization of histatin increased its biological activity approximately 1,000-fold compared to linear histatin. These studies suggest that histatins could potentially be used for the development of new wound-healing medications.

43. Which statement is true?
- A. The tissue factor impairs healing of wounds in the oral cavity.
  - B. The saliva epidermal growth factor plays an important role in fast healing of wounds in the oral cavity.
  - C. The wound healing in the oral cavity is delayed in the presence of leucocyte protease inhibitor.
  - D. Cyclic histatin demonstrates weaker biological activity compared to a linear one.
  - E. None of the above answers is true
44. Which of the statements is NOT true:
- A. Wounds in the oral cavity heal faster and with more scarring compared to skin wounds.
  - B. Salivary exosomes contain tissue factor.
  - C. Salivary epidermal growth factor stimulates proliferation of oral mucosa epithelial cells.
  - D. Histatin does not stimulate cell proliferation.
  - E. Cyclic histatin potently stimulates cellular migration and wound closure.
45. The authors suggest that:
- A. The oral cavity creates specific environment for quick wound healing.
  - B. Quick wound healing depends on the presence of saliva.
  - C. There are many factors in saliva that enhance wound healing and reduce scarring.
  - D. Some of the protein components of saliva could represent promising new wound healing medications.
  - E. All answers are true
46. The work cycle of a beating heart is formed by continuous sequential pattern of repeating contraction (systole) and relaxation (diastole) phases. At a heart rate of 65 beats/min, the duration of systole is 0.27 sec. What is the duration of diastole?
- A. 0.33 sec
  - B. 0.48 sec
  - C. 0.65 sec
  - D. 0.78 sec
  - E. 0.95 sec

47. At a heart rate of 200 beats/min, the duration of diastole decreases to 0.14 sec. At the above mentioned heart rate, the systole phase decreases to:

- A. 0.06 sec
- B. 0.1 sec
- C. 0.16 sec
- D. 0.2 sec
- E. 0.26 sec

**CHEMISTRY****The following information refers to questions no. 48 – 50**

The four quantum numbers  $n$ ,  $l$ ,  $m$ , and  $s$  specify the complete and unique quantum state of a single electron in an atom, called its wave function or orbital.

The principal quantum number  $n$  designates the principal electron shell. Because  $n$  describes the most probable distance of the electrons from the nucleus, the larger the number  $n$  is, the farther the electron is from the nucleus, the larger the size of the orbital, and the larger the atom is.  $n$  can be any positive integer starting at 1, as  $n = 1$  designates the first principal shell (the innermost shell). The first principal shell is also called the ground state, or lowest energy state. As the energy of the electron increases, so does the principal quantum number, e.g.,  $n = 3$  indicates the third principal shell,  $n = 4$  indicates the fourth principal shell, and so on. The orbital angular momentum quantum number  $l$  determines the shape of an orbital, and therefore the angular distribution. The number of angular nodes is equal to the value of the angular momentum quantum number  $l$ . Each value of  $l$  indicates a specific s, p, d, f subshell. The value of  $l$  is dependent on the principal quantum number  $n$ . It takes the values from 0 to  $n-1$  e.g. for  $n = 2$ , the values of  $l$  are 0 and 1. The number of values of the orbital angular number  $l$  can also be used to identify the number of subshells in a principal electron shell:

To identify what type of possible subshells  $n$  has, these subshells have been assigned letter names. The value of  $l$  determines the name of the subshell:

Name of Subshell	Value of $l$
s subshell	0
p subshell	1
d subshell	2
f subshell	3

We can designate a principal quantum number,  $n$ , and a certain subshell by combining the value of  $n$  and the name of the subshell (which can be found using  $l$ ). For example, 3p refers to the third principal quantum number ( $n = 3$ ) and the p subshell ( $l = 1$ ) (Anastasiya Kamenko, Tamara Enriquez, Mandy Lam, Craig Fisher *Chemistry LibreText*).

48. If  $l = 5$ , how many angular nodes does the atom have?

- A. 4
- B. 6
- C. 5
- D. 1
- E. 3

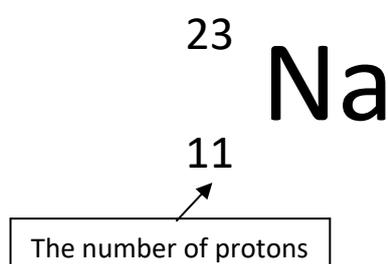
49. What is the name of the orbital with quantum numbers  $n = 5$  and  $l = 1$ ?

- A. 4f
- B. 5p
- C. 3f
- D. 2d
- E. 4d

50. What is the name of the orbital(s) with quantum number  $n = 2$ ?

- A. s, p
- B. s
- C. p
- D. d
- E. s, p, d

51. The shells are labeled alphabetically with the letters used (starting from the closest to the nucleus, we have: K, L, M, N, O, P, Q). To calculate the maximum number of electrons in each shell, the formula  $2n^2$  can be used (Dan Berger Re: *Why do electron shells have set limits?* madsci.org, 17 March 1999).

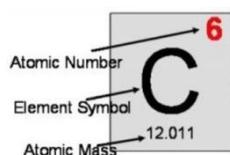


Atoms are composed of particles called protons, electrons, and neutrons. Protons carry a positive electrical charge, electrons carry a negative electrical charge, and neutrons carry no electrical charge at all. The atom is electrically neutral.

Indicate the correct notation of the electron configuration of P atom:

- A.  $K^{15}$
- B.  $K^2L^8M^6$
- C.  $K^2L^8M^5$
- D.  $K^{16}$
- E.  $M^{15}$

52. The mass of an atom, expressed in grams, is called the atomic mass. The mass of a chemical compound is equal to the sum of the masses of its individual components expressed in grams. The law of constant composition (also known as the law of definite proportions) of a chemical compound states that the mass ratio of elements in a chemical compound is a constant and characteristic value for a given compound. The percentage composition of a chemical compound is determined by the percentage of masses of individual elements in this compound (Kaznowski and Pazdro *Chemistry*).



Calculate the percentage composition of sulphur oxide in which weight ratio of sulphur to oxygen is 2 to 3. Indicate the proper chemical formula of this oxide.

- A.  $\text{SO}_2$
- B.  $\text{SO}_3$
- C.  $\text{S}_2\text{O}_3$
- D.  $\text{SO}$
- E.  $\text{S}_2\text{O}_5$

**The following information refers to questions no. 53 and 54**

A Lewis electron dot diagram is a representation of the valence electrons (outer shell electrons that can participate in the formation of a chemical bond if the outer shell is not closed) of an atom that uses dots around the symbol of the element. The number of dots equals the number of valence electrons in the atom. These dots are arranged to the right and left, and above and below the symbol. For example, the Lewis electron dot diagram for calcium is simply

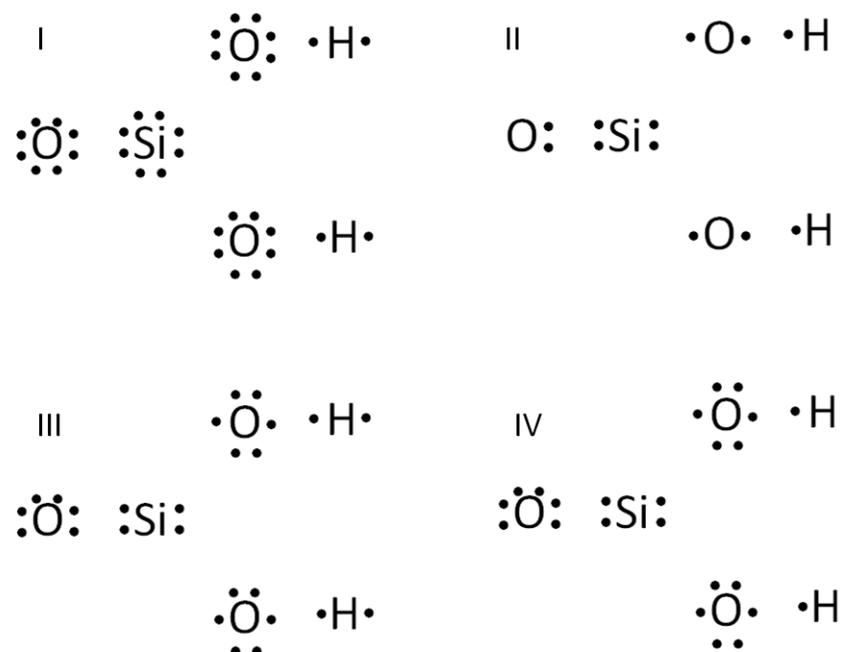


A covalent bond is formed when the atoms share a pair(s) of electrons (covalent bonding occurs in most non-metal elements, and in compounds formed between non-metals). These shared electrons are found in the outer shells of the atoms. Usually, each atom contributes one electron to the shared pair of electrons. For many molecules, the sharing of electrons allows each atom to attain the equivalent of a full outer shell (the octet and in the case of hydrogen - doublet), corresponding to a stable electronic configuration (Campbell, Neil A.; Williamson, Brad; Heyden, Robin J. (2006). *Biology: Exploring Life*)

An ionic bond is the complete transfer of valence electron(s) between atoms. It is a type of chemical bond that generates two oppositely charged ions. In ionic bonds, the metal loses electrons to become a positively charged cation, whereas the non-metal accepts those electrons to become a negatively charged anion. Ionic bonds require an electron donor, often a metal, and an electron acceptor, a non-metal (*Chemistry LibreText*).

The number of valence electrons of an element can be determined by the periodic table group (vertical column) in which the element is categorized. With the exception of groups 3–12 (the transition metals), the units digit of the group number identifies how many valence electrons are associated with a neutral atom of an element listed under that particular column (*Chemistry LibreText*).

53. Indicate the correct electron dot structure of  $\text{H}_2\text{SiO}_3$  :



- A. I
- B. II
- C. III
- D. IV
- E. Neither of the answers is correct

54. Which statement is true for task no. 54

- A. The bonds between H and O are covalent, and the bonds between Si and O are ionic.
- B. The bonds between O and H are ionic, and the bonds between Si and O are covalent.
- C. All bonds are covalent.
- D. All bonds are ionic.
- E. The bonds between O and H are of mixed nature (covalent and ionic).

55. Chemical transformations are represented by chemical equations. Chemical reactions are frequently written as an equation, using chemical symbols. The reactants are displayed on the left side of the equation and the products are shown on the right, with the separation of either a single or double arrow that signifies the direction of the reaction. Every chemical equation adheres to the law of conservation of mass, which states that matter cannot be created or destroyed. Therefore, there must be the same number of atoms of each element on each side of a chemical equation (*Boundless Chemistry Steve Lower's Website*).

The substances react with each other in a strictly defined quantitative ratio, thus to balance an equation, it is necessary that the number of atoms on the left side of the equation is equal to the number on the right. In a balanced reaction, both sides of the equation have the same number of elements. The stoichiometric coefficient is the number written in front of atoms, ions and molecules in a chemical reaction to balance the number of each element on both the reactant and product sides of the equation (Joseph Nijmeh , Mark Tye *Chemistry LibreText*)

Choose a properly balanced chemical equation:

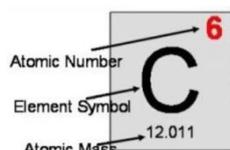
- A.  $\text{NaOH} + 2\text{F}_2 \rightarrow 2\text{NaF} + \text{OF}_2 + \text{H}_2\text{O}$
- B.  $\text{NaOH} + \text{F}_2 \rightarrow \text{NaF} + \text{OF}_2 + \text{H}_2\text{O}$
- C.  $2\text{NaOH} + \text{F}_2 \rightarrow 2\text{NaF} + \text{OF}_2 + \text{H}_2\text{O}$
- D.  $2\text{NaOH} + 2\text{F}_2 \rightarrow 2\text{NaF} + \text{OF}_2 + 2\text{H}_2\text{O}$
- E.  $2\text{NaOH} + 2\text{F}_2 \rightarrow 2\text{NaF} + \text{OF}_2 + \text{H}_2\text{O}$

**The following information refers to questions no. 56 and 57**

To determine the mass of atoms, we use a unit called the atomic unit of mass (u).  $1\text{g}$  of the atoms =  $6.02 \times 10^{23}\text{u}$  and  $1\text{u} = 1.66 \times 10^{-24}\text{g}$ . The mass of an atom, expressed in grams, is called the atomic mass. The mass of a chemical compound is equal to the sum of the masses of its individual components expressed in grams. The law of constant composition of a chemical compound states that the mass ratio of elements in a chemical compound is a constant and characteristic value for a given compound. The percentage composition of a chemical compound is determined by the percentage of masses of individual elements in this compound.

A mole of a substance is the amount of this substance in which there are  $6.022 \times 10^{23}$  discrete entities. 1 mole of any element contains the same number of atoms as 1 mole of any other element. The masses of 1 mole of different elements are different since the masses of the individual atoms are different. The molar

mass of an element (or compound) is the mass in grams of 1 mole of that substance and it is expressed in units of grams per mole (g/mol).



56. Calculate the number of moles of CaO in the sample containing  $5 \cdot 10^{23}$  CaO molecules:

- A. 0.83
- B. 1.21
- C. 0.415
- D. 0.4
- E. 5

57. Calculate the mass of CaO in the sample from the task no. 56

- A. 6.76u
- B. 46.48u
- C. 22.4u
- D. 23.24
- E. 36u

58. Molar concentration ( $C_m$ ) is a measure of the concentration of a chemical species, in particular of a solute in a solution, in terms of the amount of substance per unit volume of solution. In chemistry, the most commonly used unit for molarity is the number of moles per litre, having the unit symbol mol/L or  $\text{mol} \cdot \text{dm}^{-3}$  in SI unit ("Typography of unit symbols for Molar and Liter in siunitx". *TeX - LaTeX Stack Exchange*).

Calculate the molar concentration of the solution obtained by dissolving 60g of sodium hydroxide NaOH in 240g of water (the density of the obtained solution was  $1.2 \text{ g/cm}^3$ ). Use the additional information provided for the questions 56 and 57:

- A.  $2.5 \text{ mol} \cdot \text{dm}^{-3}$
- B.  $3 \text{ mol} \cdot \text{dm}^{-3}$
- C.  $1.5 \text{ mol} \cdot \text{dm}^{-3}$
- D.  $6 \text{ mol} \cdot \text{dm}^{-3}$
- E.  $4 \text{ mol} \cdot \text{dm}^{-3}$

**The following information refers to questions no. 59 and 60**

Percent concentration (C%) by mass is given as the mass of solute divided by the total mass of the solution and multiplied by 100%.

Concentration can be increased by dissolving more solute in a given volume of solution or by allowing some of the solvent to evaporate. Concentration can be decreased by adding more solvent to a given volume of solution. The density of the solution is a physical quantity and means the mass of a given volume unit of the solution. This value changes with temperature.

The density of the solution can be expressed in different units, for example:  $\text{g/cm}^3$ ,  $\text{g/dm}^3$ ,  $\text{kg/dm}^3$  (Bettesize *Calculations in Chemistry*).

59. Calculate how many grams of NaCl solution with a concentration of 3.5% should be evaporated to obtain 1g of NaCl.

- A. 27.57g
- B. 28.57g
- C. 35g
- D. 3.5g
- E. 1g

60. How many grams of salicylic acid does  $500\text{cm}^3$  of salicylic solution with a density of  $0.8\text{g/cm}^3$  and a concentration of 2% contain?

- A. 0.4g
- B. 8g
- C. 4g
- D. 250g
- E. 0.04g

The following information refers to questions no. 61 – 62

The hydrocarbons can be divided into the following groups:

Saturated

alkanes



cycloalkanes

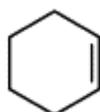


Unsaturated

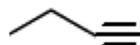
alkenes



cycloalkenes



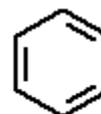
alkynes



cycloalkynes



arenes

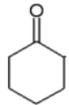


The table below matches the chosen functional groups among the organic compounds with the exemplary formulas of organic compounds and the names of the class of the compounds .

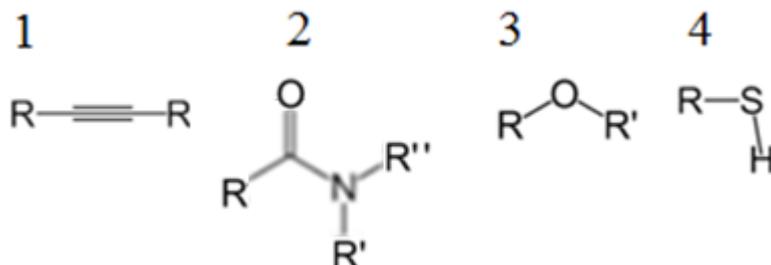
**Table 2.**

Functional group	Class of compound	Examples
Hydroxyl R-OH	Alcohols	
Hydroxyl Ar-OH	Phenols	
Thiol -SH	Thiols	
R'-O-R''	Ethers	
Amino -NH <sub>2</sub>	Amines	primary secondary tertiary
Carbonyl -HC=O	Aldehydes	
Carbonyl -C=O	Ketones	
Carboxyl -COOH	Carboxylic acids	
Ester -COOR	Esters	
Amide -CONH <sub>2</sub>	Amides	

\*R- aliphatic side chain; Ar – aromatic chain, R', R'' aliphatic or aromatic side chain

61. What class of compounds are those:  $\text{CH}_3\text{COCH}_3$  and  ?
- Alkenes
  - Ketones
  - Aldehydes
  - Esters
  - Carboxylic acid and phenol

62. The classes or groups of the compounds 1-4 are correctly named in:



- 1- alkenes; 2 – amides; 3 – ethers; 4 – thioethers
- 1- alkynes; 2 – carboxylic acids; 3 – esters; D – thioethers
- 1- alkanes; 2 – amines; 3 – ethers; 4 – thiols
- 1- alkynes; B – amides; 3 – ethers; 4 – thiols
- 1- alkenes; B – amines; 3 – esters; 4 – thioesters

The following information refers to questions no. 63 – 64

Presented below are the names of three main types of organic reactions and their mechanisms.

### Types of organic reactions



#### SUBSTITUTION

nucleophilic  
electrophilic  
free radical



#### ADDITION

nucleophilic  
electrophilic

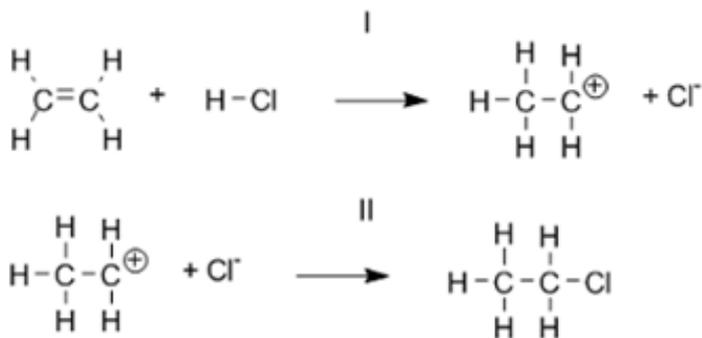


#### ELIMINATION

E1  
E2

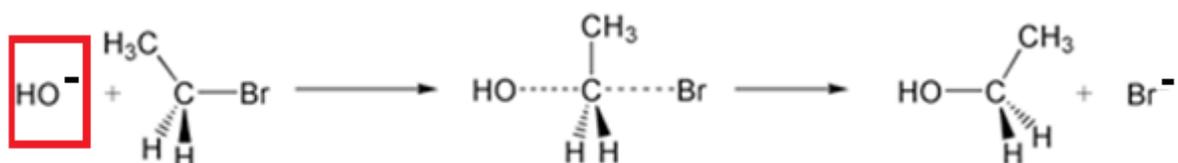
The characteristic chemical entity occurring during the reaction with electrophilic mechanism is called carbocation, and it has the positive charge present on one of the carbons of the reacting compound. The characteristic chemical entity taking part in the reaction with nucleophilic mechanism is called nucleophile – a molecule or a group in which there is an excess of electrons, and which can be a donor under appropriate conditions [e.g.  $\text{CH}_3\text{S}^-$ ,  $(\text{CH}_3)_3\text{N}$ ,  $\text{OH}^-$ ]. Free radicals created in the presence of UV light are characteristic for substitution with free radical mechanism [e.g.  $\bullet\text{Br}$ ,  $\bullet\text{CH}_3\text{-CH}_3$ ]

63. Name the mechanism of the two-step addition reaction presented below:



- A. electrophilic
- B. nucleophilic
- C. free radical
- D. E1
- E. E2

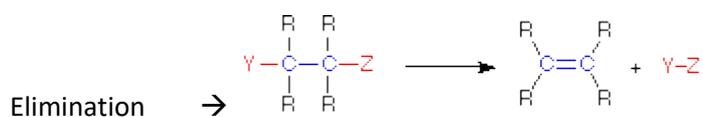
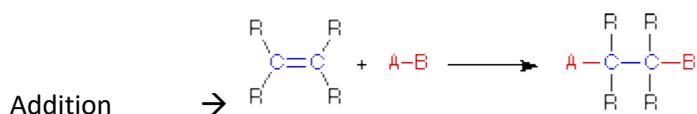
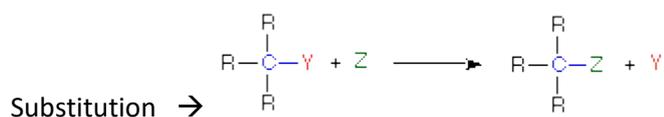
64. The chemical entity in the frame is called:



- A. radical
- B. carbocation
- C. nucleophile
- D. carbanion
- E. None of the answers is correct

The following information refers to questions no. 65 – 66

Presented below are the schematic equations for three main classes of organic reaction listed as substitution, addition, and elimination:



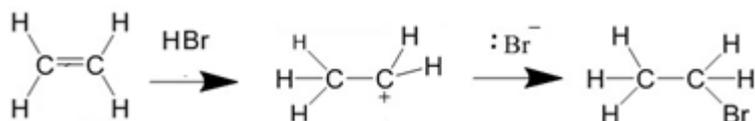
R – aliphatic/aromatic side chain

Source of the graphic representation of the reactions:

[https://chem.libretexts.org/Bookshelves/Organic\\_Chemistry/Map%3A\\_Organic\\_Chemistry\\_\(Wade\)/04%3A\\_The\\_Study\\_of\\_Chemical\\_Reactions/5.01%3A\\_Introduction](https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Wade)/04%3A_The_Study_of_Chemical_Reactions/5.01%3A_Introduction)

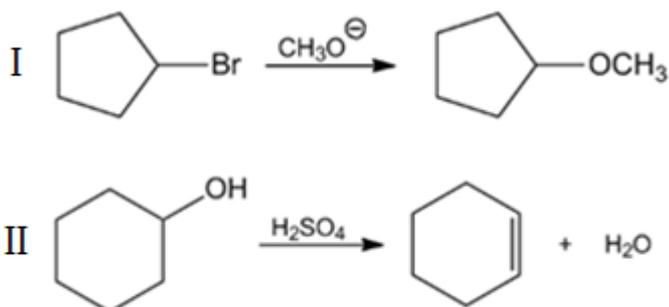
Substitution is the type of reaction characteristic for arenes, while the addition reaction will occur in the presence of classic double bond in the substrate.

65. Choose the correct **type** of reaction for the following example presenting the substrate, semi-product, and product of the organic reaction:



- A. substitution
- B. addition
- C. elimination
- D. free radical
- E. rearrangement

66. Indicate the correct reaction **type(s)** for the following examples:



- A. I – substitution; II- elimination
- B. I, II – substitution;
- C. I, II- elimination
- D. I – addition; II- elimination
- E. I- substitution; II- – addition

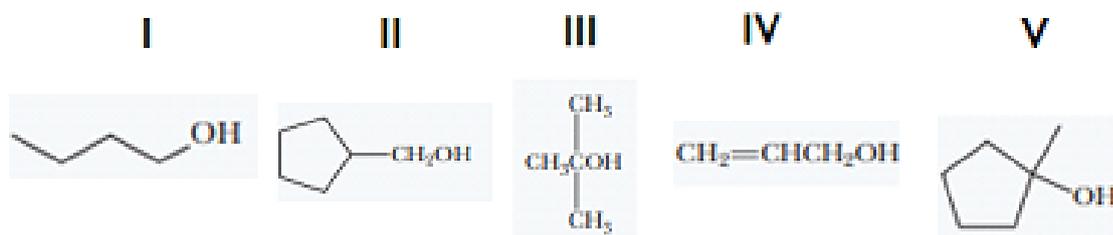
**The following information refers to questions no. 67– 69**

Tetravalency is one of the properties of carbon in organic compounds. Carbon can form up to 4 bonds with different elements. Carbon can be classified as primary, secondary, tertiary, or quaternary, depending on the number of carbon atoms it is bonded to. This classification only applies to saturated carbons. Primary carbon (I) occurs when carbon is attached to one other carbon, secondary carbon (II) occurs when carbon is attached to two other carbons, etc.

Alcohols are organic compounds containing at least one hydroxyl group combined with a carbon atom. The order of the alcohol: I–first, I-second, III- third, is equal to the order of the carbon atom to which the hydroxyl group is connected. The alcohols can be oxidized to aldehydes (I order alcohols – primary alcohols), ketones (II order alcohols- secondary alcohols) or carboxylic acids. III order alcohols (tertiary) do not undergo simple oxidation (without breaking C-C bond). The oxidizing agents acting on the alcohols may be:  $\text{KMnO}_4$  or  $\text{K}_2\text{Cr}_2\text{O}_7$ .

Alcohols may be substrates to esterification reactions that result in creation of an ester bond with carboxylic group of the acid. Like amide bonds, ester bonds can be broken in the process of hydrolysis.

Figures below (from I to V) represent formulas of certain alcohols



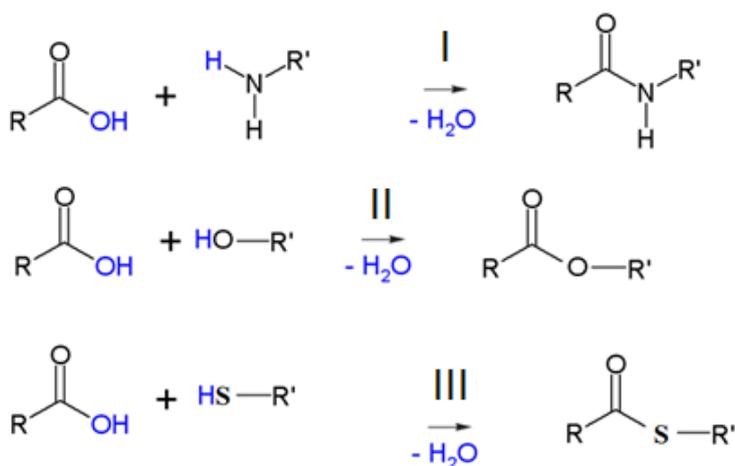
67. The formulas that represent the primary alcohols are:

- A. I and IV
- B. II and V
- C. I, II and III
- D. I, II and IV
- E. I, II, III and V

68. The formulas that represent the alcohols which will not undergo simple oxidation with  $K_2Cr_2O_7$  are:

- A. I
- B. I, IV
- C. II, III
- D. II, V
- E. III, V

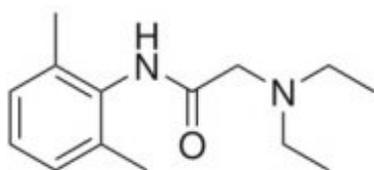
69. Which reaction equation(s) represent(s) the ester formation? (You may use **Table 2** for aid).



- A. I
- B. II
- C. Both I and II
- D. Both I and III
- E. None of the proposed equations

The following information refers to questions no. 70-74

Lidocaine is a commonly used local anesthetic suitable for infiltration, blocking, and surface anesthesia in dentistry. The skeleton representation of lidocaine is shown below.



70. What is the chemical formula of lidocaine?

- A.  $C_{12}H_{22}N_2O$
- B.  $C_{14}H_{11}N_2O$
- C.  $C_{15}H_{11}N_2O$
- D.  $C_{14}H_{22}N_2O$
- E. CHNO

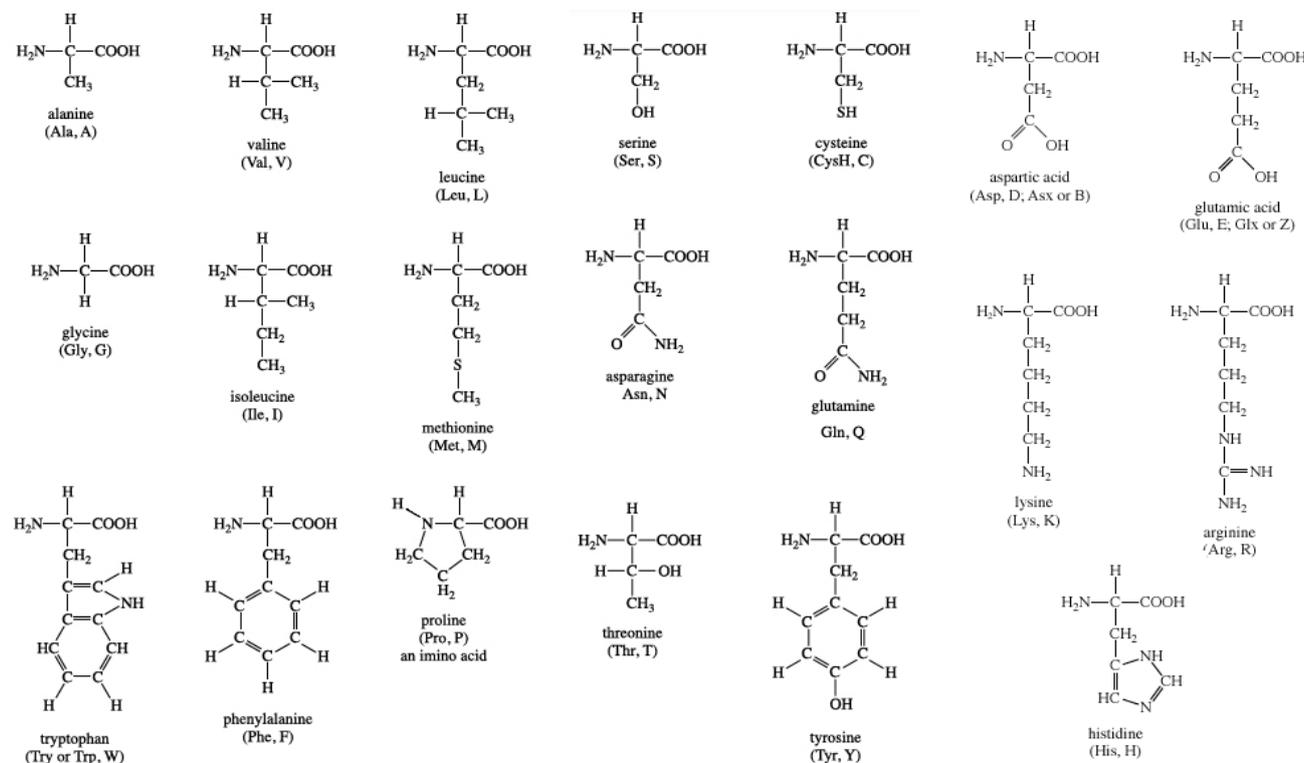
For questions 71-74, you may use **Table 2** as well as the information to questions 67-69 for aid.

Indicate whether the statements are TRUE (T) or FALSE (F) for lidocaine.

- 71. Theoretically, lidocaine can undergo esterification with ethanol or acid. T/F
- 72. Theoretically, lidocaine can undergo hydrolysis of one of the bonds. T/F
- 73. Lidocaine structure contains an aromatic component. T/F
- 74. Lidocaine structure contains an amide bond and a tertiary amine. T/F

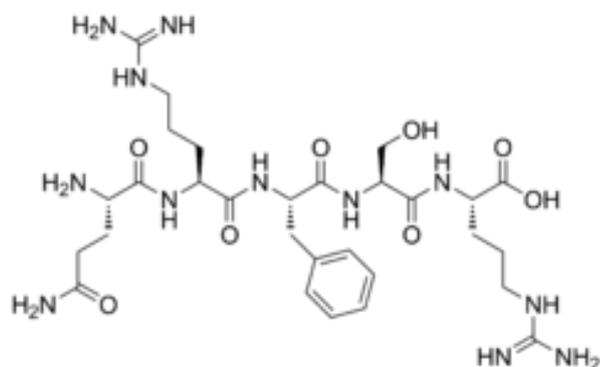
## The following information refers to questions no. 75-78

The picture below shows select formulas, names, and three-letter abbreviations of amino acids that can be present in human proteins. <https://www.britannica.com/science/amino-acid>



At the turn of the 20th century, a German chemist Emil Fischer was the first to propose the linking together of amino acids that he called a peptide bond. They can be linked by a condensation reaction in which an -OH is lost from the carboxyl group of one amino acid along with a hydrogen from the amino group of a second amino acid, forming a molecule with an amide bond: -COHN-. (<https://www.britannica.com/science/amino-acid/Amino-acid-reactions#ref997074>).

75. Opiorphin is an endogenous chemical compound isolated from human saliva. Some research shows that the compound has a painkilling effect greater than that of morphine. It is a relatively simple molecule consisting of a five-amino acid polypeptide, (<https://en.wikipedia.org/wiki/Opiorphin>). Its structure is presented below:



**What is the amino acid composition of Opiorphin?**

- A. Gly – Arg – Tyr – Thr – Arg
  - B. Gly – Lys – Tyr – Ser – Lys
  - C. Gln – Lys – Phe – Ser – Lys
  - D. Gln – Arg – Phe – Ser – Arg
  - E. Gln – Lys – Phe – Thr – Arg
76. Structural isomers of organic compounds have the same molecular formula (composition) but a different way of bonding atoms with each other. **Indicate the pair of structural isomers among the amino acids:**
- A. Asn and Asp
  - B. Leu and Ile
  - C. Ala and Gly
  - D. Trp and His
  - E. Thr and Ser

**Additional information for question no. 77**

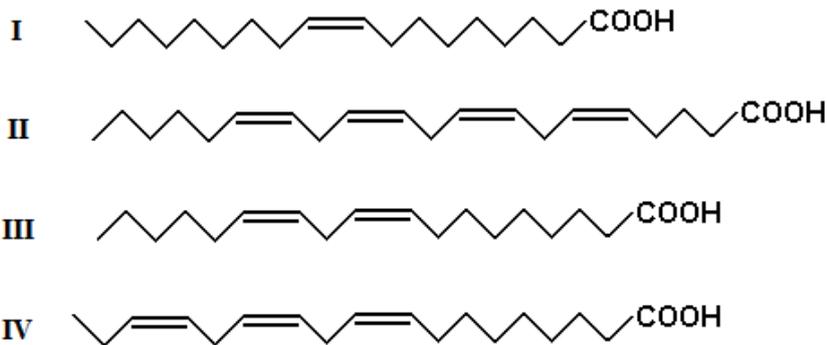
Schiff bases are a popular class of compounds with interesting biological properties. Therapeutically, Schiff bases and their metal complexes have been reported to exhibit a wide range of biological activities such as antibacterial including antimycobacterial, antifungal, antiviral, antimalarial, anti-inflammatory, antioxidant, pesticidal, cytotoxic, enzyme inhibitory, and anticancer including DNA damage ([source: doi: 10.1080/13543776.2017.1252752](https://doi.org/10.1080/13543776.2017.1252752)). An exemplary reaction equation between two substrates that results in Schiff base formation is presented below:



77. Indicate the statement that is true for the presented reaction equation:
- A. An aldehyde and a primary aromatic amine are used as substrates.
  - B. One of the steps of the reaction is dehydration (-H<sub>2</sub>O).
  - C. The product of the reaction has a characteristic double bond between nitrogen and carbon.
  - D. The same reaction could occur between acetic aldehyde and –NH<sub>2</sub> group of the lysine.
  - E. All of the above are correct.
78. Indicate the **false** statement regarding the amino acids structure (*you may use **Table 2** for aid*):
- A. Asparagine and glutamine have the amide group in the side chain.
  - B. Proline is a secondary amine.
  - C. Tryptophan and phenylalanine are both aromatic amino acids.
  - D. Methionine and cysteine are both thiols.
  - E. Tyrosine has a phenol group in the structure.

79. The omega-reference system of naming fatty acids indicates the number of carbons, the number of double bonds, and the position of the double bond closest to the omega carbon (the carbon in terminal methyl group), counting from the omega carbon. Omega-3 fatty acids are polyunsaturated fatty acids characterized by the presence of a double bond, three atoms away from the terminal methyl group, counting from the omega carbon. (source: [https://library.med.utah.edu/NetBiochem/FattyAcids/4\\_1c.html](https://library.med.utah.edu/NetBiochem/FattyAcids/4_1c.html))

Choose the Omega-3 acid/s from the following formulas:

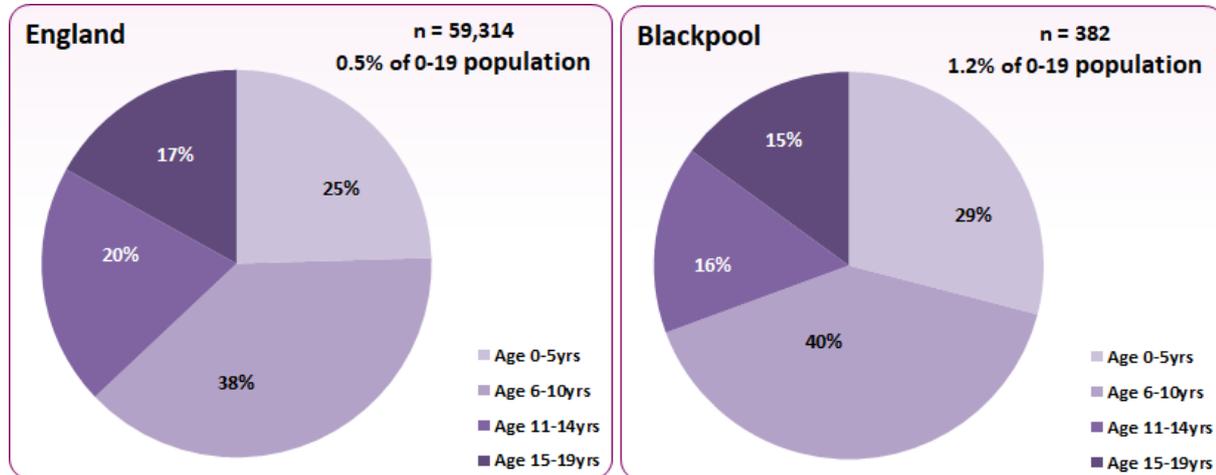


- A. only I
- B. only IV
- C. I and IV
- D. II and III
- E. III and IV

## LOGIC

80. Look at the figure below and decide which sentence is true.

**Figure 3: Hospital admissions - proportion of hospital admissions for simple tooth extraction in children and young people by age group, England and Blackpool: 2017/18**



Source: <https://www.blackpooljsna.org.uk/Developing-Well/Children-and-young-peoples-health/Dental-Health.aspx>

- A. In Blackpool, 29% of population in the 0-19 age range was hospitalized because of teeth extraction in 2017/18.
- B. Both in England and in Blackpool, the highest percentage of all extractions in 2017/18 was in the age group 6-10 years.
- C. In Blackpool, the relative frequency of children and young people who were hospitalized due to tooth extraction in 2017/18 was higher than in England.
- D. 37% of Blackpool children admitted to a hospital for tooth extraction in 2017/18 were over 10 years old.
- E. 31% of Blackpool children who had a tooth extraction in 2017/18 were aged over 10 years.

Read the following passage and decide if the sentences below are true or false

### Coronavirus disease 2019 (COVID-19)

Coronaviruses are a family of viruses that can cause illnesses such as the common cold, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). In 2019, a new coronavirus was identified as the cause of a disease outbreak that originated in China. The virus is now known as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease it causes is called coronavirus disease 2019 (COVID-19). In March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a pandemic. (...)

Signs and symptoms of coronavirus disease 2019 (COVID-19) may appear 2 – 14 days after exposure. This time after exposure and before having symptoms is called the incubation period. Common signs and symptoms can include: fever, cough, tiredness. Early symptoms of COVID-19 may include a loss of taste or smell. Other symptoms can include: shortness of breath or difficulty breathing, muscle aches, chills, sore throat, runny nose, headache, chest pain, pink eye (conjunctivitis). Other less common symptoms have been reported, such as rash, nausea, vomiting and diarrhea. Children have similar symptoms to adults and generally have mild illness.

The severity of COVID-19 symptoms can range from very mild to severe. Some people may have only a few symptoms, and some people may have no symptoms at all. Some people may experience worsened symptoms, such as worsened shortness of breath and pneumonia, about a week after symptoms start.

People who are older have a higher risk of serious illness from COVID-19, and the risk increases with age. People who have existing chronic medical conditions also may have a higher risk of serious illness.

Source: <https://www.mayoclinic.org/diseases-conditions/diabetes/symptoms-causes/syc-20371444>'

- |   |      |       |
|---|------|-------|
| 81. Coronavirus was identified for the first time in 2019.  | True | False |
| 82. Early symptoms of COVID-19 are a loss of taste or smell only.   | True | False |
| 83. The risk of severe COVID-19 is lower in younger people, including children, and in people without chronic conditions. | True | False |
| 84. Incubation period is the time from exposure to the virus to the diagnosis of COVID-19.                                | True | False |
| 85. Pandemic outbreak of COVID-19 was declared after the recognition of presence of COVID-19 in Europe.                   | True | False |
| 86. Children and adults have similar symptoms of SARS-Cov2 infection.   | True | False |

87. **There are five old trees in the park: an oak, a hornbeam, a linden, a birch, and an elm. The hornbeam is neither the tallest nor the shortest. The linden is taller than the elm. Only one tree is taller than the oak and it is not the birch. The birch is not shorter than the hornbeam. Which tree is the shortest?**
- A. the oak,
  - B. the hornbeam,
  - C. the linden,
  - D. the birch,
  - E. the elm

**The following information refers to questions no. 88-92**

**Five roommates: Rose, Sonia, Tatiana, Uma, and Veronica each do one housekeeping task: mopping, sweeping, laundry, vacuuming, or dusting one day a week; Monday through Friday.**

- \* Veronica does not vacuum and does not do her task on Tuesday.
- \* Sonia does the dusting, and does not do it on Monday nor Friday.
- \* Mopping is done on Thursday.
- \* Tatiana does her task, which is not vacuuming, on Wednesday.
- \* The laundry is done on Friday, and not by Uma.
- \* Rose does her task on Monday.

88. **What task does Tatiana do on Wednesday?**

- A. vacuuming
- B. dusting
- C. mopping
- D. sweeping
- E. laundry

89. **Who is responsible for mopping?**

- A. Rose,
- B. Sonia,
- C. Tatiana,
- D. Uma,
- E. Veronica

90. **When does Sonia do the dusting?**

- A. Monday
- B. Tuesday
- C. Wednesday
- D. Thursday
- E. Friday

91. **What day does Veronica do her task?**

- A. Monday
- B. Tuesday
- C. Wednesday
- D. Thursday
- E. Friday

92. **On what day is the vacuuming done?**

- A. Monday
- B. Tuesday
- C. Wednesday
- D. Thursday
- E. Friday

93. **Tom collects glass miniatures of animals. He received 20 new miniatures from his friends for his birthday. His sister Jill gave him half of the number he received from friends, and his mother added one tenth of the sum of the miniatures received from friends and Jill together. Tom is very happy now – his collection is twice as numerous as before the birthday. How many animal miniatures has Tom got now?**

- A. 30
- B. 33
- C. 36
- D. 60
- E. 66

94. **Indicate the number completing the sequence:**

**0, 7, 7, 14, 21, 35, 56, 91, ....**

- A. 91
- B. 98
- C. 105
- D. 147
- E. 170

The following information refers to questions no. 95 – 99

Which conclusions are true based on the statements below?

Statements:

Some flowers are blue.

All blue things are big.

No big thing is cube-shaped.

- |  |      |       |
|--|------|-------|
| 95. All blue things are cube-shaped.       | True | False |
| 96. Some flowers might not be cube-shaped. | True | False |
| 97. Some blue things are flowers.          | True | False |
| 98. All big things are flowers.            | True | False |
| 99. Some cube-shaped things might be blue. | True | False |

100. Two men are following their colleague, John, who was travelling in the desert to find an oasis. At every stop, he left a message with information on the next leg of his journey. John started close to a big pyramid and his first note was "Go 5 km to the West, turn left and go for 2 km". Next message said: "Go East for 1 km, turn left and walk for 4 km, next turn right and go for 2 km. The oasis with fresh water is at the end of this route". In which direction relative to the big pyramid is the oasis located?

- A. East
- B. South
- C. North-East
- D. North-West
- E. South-West

**THE KEY**

1. D; 2. D; 3. B; 4. E; 5. C; 6. A; 7. D; 8. B; 9. C; 10. B; 11. C; 12. B; 13. B; 14. B; 15. B; 16. B;  
17. D; 18. A; 19. E; 20. D; 21. E; 22. D; 23. B; 24. F; 25. T; 26. F; 27. T; 28. T; 29. C; 30. E; 31.  
A; 32. D; 33. A; 34. B; 35. A; 36. B; 37. E; 38. C; 39. A; 40. E; 41. C; 42. B; 43. B; 44. A; 45. E;  
46. C; 47. C; 48. C; 49. B; 50. A; 51. C; 52. B; 53. D; 54. C; 55. E; 56. A; 57. B; 58. D; 59. A; 60.  
B; 61. B; 62. D; 63. A; 64. C; 65. B; 66. A; 67. D; 68. E; 69. B; 70. D; 71. F; 72. T; 73. T; 74. T;  
75. D; 76. B; 77. E; 78. D; 79. B; 80. C; 81. F; 82. F; 83. T; 84. F; 85. F; 86. T; 87. E; 88. D; 89.  
D; 90. B; 91. E; 92. A; 93. E; 94. D; 95. F; 96. T; 97. T; 98. F; 99. F; 100. D

## Reasoning and Critical Thinking in Pre-medical Sciences 2020 Test

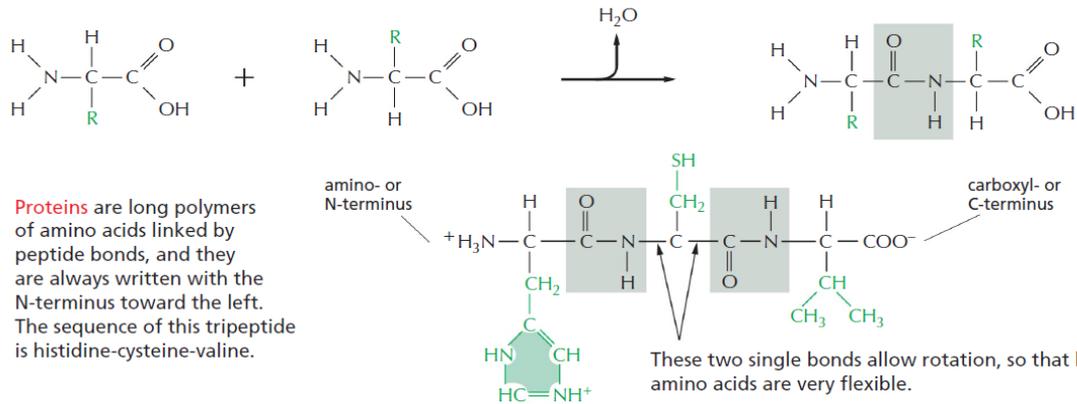
## Biology

Fig.1

## PEPTIDE BONDS

Amino acids are commonly joined together by an amide linkage, called a **peptide bond**.

**Peptide bond:** The four atoms in each *gray box* form a rigid planar unit. There is no rotation around the C-N bond.

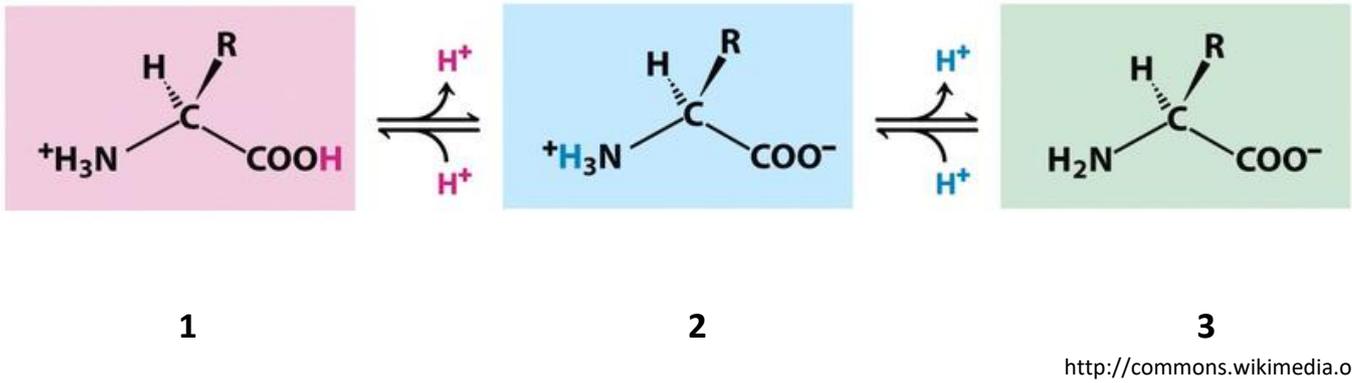


Molecular Biology of the Cell-Garland Science (2014)

- Proteins are synthesized by translation from amino acids that connect with a peptide bond. A characteristic feature of a peptide bond is its rigidity (Fig.1). Please indicate **TRUE** statements regarding this feature.
 

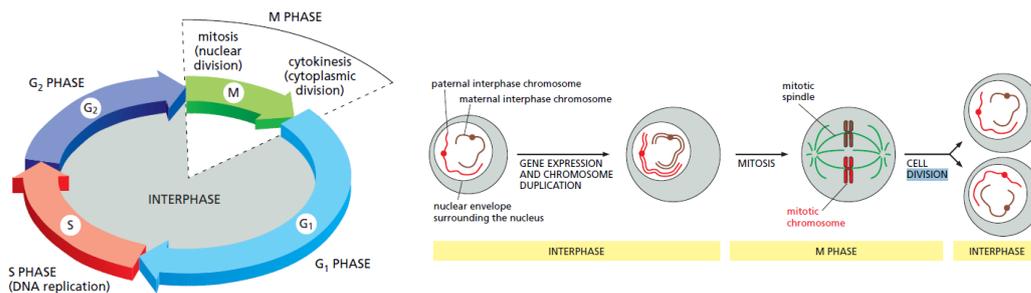
Peptide bond rigidity results from:

  - the formation of resonance forms of double bond between O-C and C-N T/F;
  - the fact that all atoms creating peptide bond remain in the same plane T/F;
  - the appearance of hydrophobic interactions between C-N T/F;
  - the appearance of ionic interactions between O-N T/F;
  - breaking double bonds T/F.
- The primary structure of the protein is the order of amino acids resulting from the genetic code. The secondary structure is reached based on the spatial interaction between peptide bonds and is a local structure, therefore there can be many  $\alpha$ -helices and  $\beta$ -sheets in the protein. The tertiary structure gives the overall shape to the protein molecule and results from the interactions of many areas of the secondary structures and the substituents they contain. The tertiary structure is formed by:
  - hydrophobic interactions.
  - salt bridges.
  - hydrogen bonds.
  - electrostatic interactions.
  - All of the above.



3. Isoelectric point of the molecule (e.g. amino acid, protein) is the pH value at which the net charge of the molecules in a solution is zero. Assign the appropriate pH values to the individual positions in Fig 2.
- A. 1). pH 7    2). pH 12    3). pH 14  
 B. 1). pH 11    2). pH 7    3). pH 1  
 C. 1). pH 1    2). pH 7    3). pH 11  
 D. 1). pH 7    2). pH 8    3). pH 9  
 E. None of the above.
4. Protein reaching an isoelectric point:
- A. will lose the ability to move in an electric field.  
 B. will lose its activity.  
 C. will gain the highest activity.  
 D. will denature.  
 E. None of the above.

**Fig.3**



Molecular Biology of the Cell-Garland Science

5. Fig. 3 shows four different phases in each eukaryotic cell cycle: G1 phase starts with the end of previous M phase and lasts till the synthesis of DNA; S phase is when replication of cellular DNA takes place; G2 phase occurs after DNA replication and is characterised with intense protein synthesis and rapid cell. These three consecutive phases are known also as interphase, and M phase containing mitosis and cytokinesis. In M phase, two coupled processes can be distinguished: mitosis – division of the amplified genetic material followed with karyokinesis (division of the nucleus) and cytokinesis (cell division into two daughter cells). Activation of each phase depends on the proper progression

and completion of the previous phase. Cells that have temporarily or reversibly stopped dividing enter a state of quiescence - G<sub>0</sub> phase.

In which of the cell cycle phases does the cell contain doubled amount of DNA?

- A. G<sub>1</sub>, S, G<sub>0</sub>
  - B. S, G<sub>2</sub>, M
  - C. G<sub>1</sub>, G<sub>2</sub>, G<sub>0</sub>
  - D. M
  - E. S
6. Considering the information shown in (Fig.3), indicate when the cell can enter the G<sub>0</sub> phase.
- A. At G<sub>1</sub> phase before reaching G<sub>1</sub>/S checkpoint.
  - B. At M phase before reaching G<sub>2</sub>/M checkpoint.
  - C. At any moment during the S phase.
  - D. At any moment during the M phase.
  - E. None of the above.
7. The predominant cause of family hypercholesterolemia is a mutation in the LDL receptor - encoding gene, located on the short arm of chromosome 19. The disease is inherited in such a way that the risk of its occurrence in children whose one parent is sick and the other is healthy amounts 50% or 100%, depending on whether the patient is heterozygous or homozygous. This means that the disease is inherited:
- A. recessive sex coupled.
  - B. recessive autosomal.
  - C. dominant sex-linked.
  - D. dominant autosomal.
  - E. None of the above.
8. Indicate all possible types of gamete genotypes produced by the AabbCc genotype, assuming that these genes inherit independently.
- A. AbC, Abc, abC, abc
  - B. AbB, AbC, ABC, abc
  - C. AAc, Bbc, abC, abc
  - D. AbC, Abc, abC, Ccb
  - E. aaa, bbb, ccc, abc
9. Anabolic processes consume energy by, among others, creating macromolecules from small building blocks. Catabolism is a phenomenon that leads to the breakdown of macromolecules into smaller elements. As a result, energy is released. In the living cell, anabolism and catabolism are closely related; they must be balanced as anabolic processes occur thanks to energy from catabolic processes. The metabolic balance in the body is called homeostasis. The following list names several cellular basic enzymatic processes.
- 1) Oxygen respiration,
  - 2) Alcohol fermentation,
  - 3) DNA replication,
  - 4) Chemosynthesis,
  - 5) Starch hydrolysis.

Indicate the answer listing **only anabolic** processes.

- A. 1, 2
- B. 1, 3
- C. 2, 3, 4
- D. 3, 4
- E. 1, 5

10. The mRNA reading frame is a series of many codons stacked side by side, starting with the START codon (usually AUG) and ending with one of the STOP codons (usually UAA, UAG or UGA). Which types of mutation from among those indicated below, involving one or two nucleotides, will affect the shift, change of the genetic information reading frame and, as a result, the possibility of another protein synthesis with a changed amino acid composition from the place of mutation.

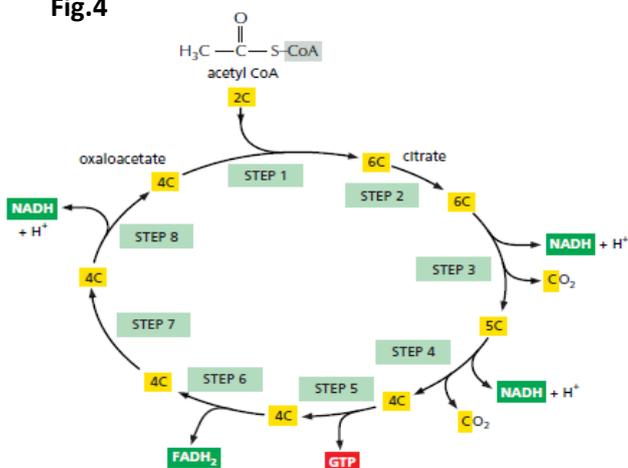
- 1) Deletion,
- 2) Insertion,
- 3) Transversion,
- 4) Transition.

- A. 1, 2
- B. 3
- C. 3, 4
- D. 4
- E. 1, 2, 3, 4

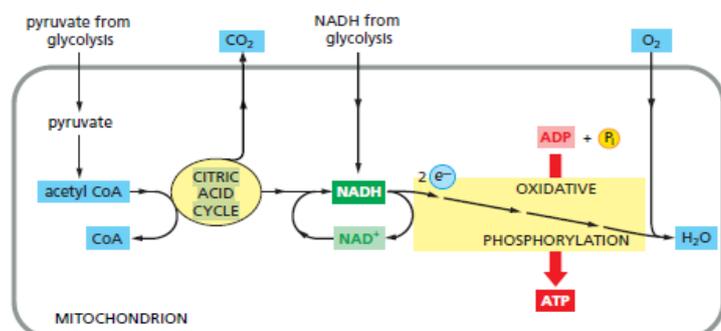
11. The phenomenon described above will have far less dangerous consequences in the case of three nucleotides because:

- A. it will be quickly repaired.
- B. it will not be noticed.
- C. the reading frame will not change.
- D. it will not affect the gene expression product.
- E. None of the above.

Fig.4

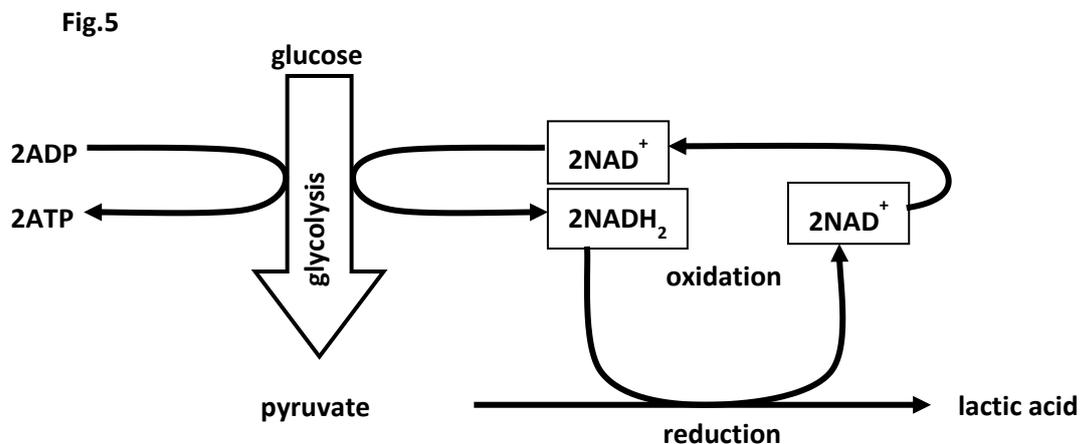


NET RESULT: ONE TURN OF THE CYCLE PRODUCES THREE NADH, ONE GTP, AND ONE FADH<sub>2</sub> MOLECULE, AND RELEASES TWO MOLECULES OF CO<sub>2</sub>

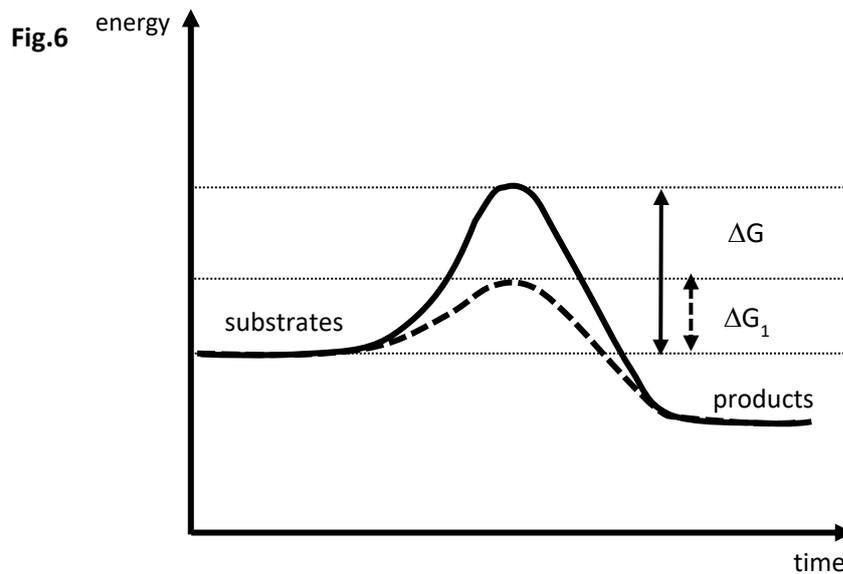


Molecular Biology of the Cell-Garland Science (2014)

12. Tricarboxylic acid cycle and its connection with oxidative phosphorylation pathway diagram is presented in Fig.4. The tricarboxylic acid cycle consists of a series of chemical reactions consuming acetyl-CoA and water, leading to reduction of  $\text{NAD}^+$  to  $\text{NADH}$ , and producing carbon dioxide as a byproduct.  $\text{NADH}$  generated during the cycle is fed into the oxidative phosphorylation pathway. The final result of these two closely-linked pathways is usable chemical energy in the form of ATP. Indicate the correct answer describing the biological significance of the tricarboxylic acid cycle.
- Decomposition of acetyl-CoA to release hydrogen and bind it to oxidizing agent.
  - Energy production in the form of GTP.
  - Production of nutrients.
  - $\text{CO}_2$  synthesis.
  - None of the above.
13. Why is the tricarboxylic acid cycle defined as the cycle linking protein, fat, and sugar metabolism?
- Because it uses a universal product of all of the above-mentioned metabolic pathways – acetyl-CoA.
  - Because it provides products for all metabolic pathways mentioned above.
  - Because it is an easily accessible cytoplasmic cycle.
  - Because it consumes large amounts of energy.
  - None of the above.



14. Based on the scheme presented in Fig. 5, indicate why in anaerobic conditions mammalian muscle begins lactic fermentation.
- Under anaerobic conditions, respiratory chain is unable to release the  $\text{NAD}^+$  necessary for glycolysis.
  - Because lactic acid improves muscle function.
  - Because lactic fermentation provides a lot of energy.
  - Because it's the only way to unblock the respiratory chain.
  - None of the above

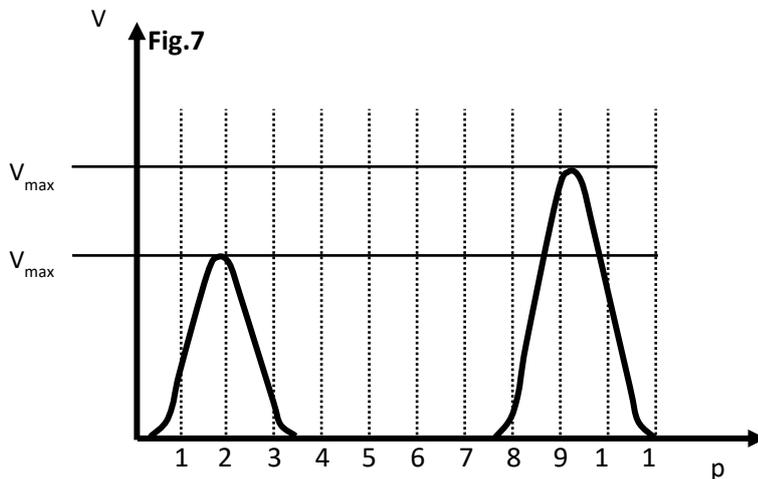


15. The scheme in Fig.6 shows changes in the energy of substrates and reaction products taking place without the participation of the enzyme, and with its participation. Please indicate the correct answer.
- Solid line – enzymatic catabolic reaction; dashed line – non-enzymatic catabolic reaction
  - Solid line – non-enzymatic catabolic reaction; dashed line – enzymatic catabolic reaction
  - Solid line – enzymatic anabolic reaction; dashed line – non-enzymatic anabolic reaction
  - Solid line – non-enzymatic anabolic reaction; dashed line – enzymatic anabolic reaction
  - None of the above.
16. Metabolic pathways are often regulated by a negative feedback loop. It means that:
- the end product of the metabolic pathway affects the last enzyme of this pathway.
  - the end product of the metabolic pathway affects the key enzyme that regulates this pathway, increasing the production of the end product.
  - the end product of the metabolic pathway affects the key enzyme that regulates this pathway, preventing the production of more end product.
  - the substrate of the metabolic pathway affects the key enzyme that regulates the start of this pathway, preventing the production of more end product.
  - None of the above.

17. Apoptosis is an active and energy-consuming process of eliminating cells no longer needed or damaged from a biological point of view. Stimuli that induce this process can be extracellular or intracellular. Apoptosis aims at preventing the selected cell from surviving, replicating DNA, cell division, rupture of the cell membrane, and releasing cellular content. It is supposed to stop local inflammation and activation of neighbouring cells. The process is strictly controlled by the expression of specific genes, the products of which are involved in apoptosis. As a result of apoptosis, the cell breaks down into spherical particles, so-called apoptotic bodies.

Based on the above information, select **ALL** processes that occur during apoptosis: 1. cell swelling; 2. cell shrinking and plasma membrane blebbing; 3. ATP synthesis; 4. nucleus rupture; 5. protein synthesis.

- A. 1, 4
- B. 2, 3, 5
- C. 1, 2, 4
- D. 4, 5
- E. None of the above



18. Fig. 7 is a graph illustrating the relationship between the enzymatic reaction rate and the optimum of pH value for two different enzymes. These enzymes cannot work in the same locations in a eukaryotic cell because:

- A. they have different values of the maximum rate of enzymatic reaction.
- B. the pH range of the optimal values of both enzymes does not coincide within the entire range of their activity.
- C. they reach the maximum value of the enzymatic rate at different pH levels.
- D. the optimal operating temperature for each enzyme is unknown to us.
- E. None of the answers is correct.

19. The cell membrane separates from the environment while allowing exchange of matter and energy with the environment.  
Which of the following cell membrane features are directly responsible for this process?  
1. semi-liquid; 2. dynamics; 3. asymmetry; 4. semi-permeability; 5. ability to fuse.
- A. 1, 2
  - B. 2, 3
  - C. 1, 3
  - D. 4, 5
  - E. None of the above
20. Knowing that the competitive inhibitor competes with the substrate for the binding site in the active center of the enzyme, we can say that:
- A. excess substrate will not matter for the inhibition reaction.
  - B. at high concentrations, the substrate may push the inhibitor out of the active center.
  - C. the inhibitor attaches to the enzyme even if the substrate is already in the active center.
  - D. None of the above is correct.
  - E. Statements A, B, and C are correct.
21. In order to change the consistency of the cytoplasm, the cell must undergo processes that are immediate, reversible, fully controlled by the cell, and relate to the local environment. Which of the following processes best meets these requirements?
- A. Gel-sol transition in colloidal solutions
  - B. Polymerization of cytoskeleton elements
  - C. Osmosis
  - D. Salting out proteins
  - E. None of the above
22. Mitochondrial inheritance means the process of:
- A. transferring mitochondrial DNA contained in an egg to an embryo during fertilization.
  - B. transferring the mitochondrial DNA contained in the sperm to the embryo during fertilization.
  - C. transferring mitochondrial DNA contained in both gametes to the embryo.
  - D. transferring mitochondrial DNA contained in placental epithelial cells to the embryo.
  - E. transferring mitochondrial DNA to the embryo at random from parents' gametes.
23. Why are fats a better source of energy in eukaryotic cells than monosaccharides?
- A. Because in the process of  $\beta$ -oxidation of single molecule of fatty acid much more acetyl coenzyme A is formed than in the process of glycolysis of a single molecule of monosaccharides.
  - B. Because they have a higher combustion temperature.
  - C. Because they are subject to a longer chemical treatment.
  - D. Because the distribution of fat is much faster.
  - E. None of the above.

The text for questions no. 24 – 28.

**Associations of the microbiome\* and esophageal disease.**

[Okereke I.](#) et al. [J Thorac Dis.](#) 2019 Aug;11(Suppl 12):S1588-S1593.

(...) The esophageal microbiome appears to have a role in the development of some disease processes, and could also serve as markers of early diseases of the esophagus. A literature review was performed examining the role of the microbiome in the development of esophageal disease. In addition, the results of several studies and experiments were included in the review. Both esophageal adenocarcinoma (EAC) and gastro-esophageal reflux disease (GERD) have increased in incidence over the last 40 years. Barrett's esophagus (BE)\*\* is a risk factor for EAC. Patients with BE appear to have a microbiome expression pattern distinct from patients without BE. The distinct pattern may be related to factors within the distal esophagus such as a more acidic environment, intraluminal stasis and other elements. It remains unclear whether the change in microflora leads to esophageal disease, or whether the disease process within the esophagus allows these particular organisms to experience overgrowth compared to other microflora. Patient factors such as body mass index (BMI)\*\*\*, diet and geographic location also appear to affect the esophageal microbiome. There is an association with the esophageal microbiome and several esophageal diseases. Future studies should examine these correlations more closely. The distinct patterns may be able to serve as a marker of early disease, and possibly lead to a mechanism for the development of esophageal disease.

\*A community of [microorganisms](#) (such as bacteria, fungi, and viruses) that inhabits a particular environment, and especially the collection of [microorganisms](#) living in or on the human body.

\*\* In Barrett's esophagus, normal tissue lining the esophagus (the tube that carries food from the mouth to the stomach) changes to tissue that resembles the lining of the intestine. Such change is associated with chronic GERD.

\*\*\* BMI = [body mass](#) divided by the [square](#) of the [body height](#), and is universally expressed in [units](#) of kg/m<sup>2</sup>, resulting from mass in [kilograms](#) and height in [meters](#).

24. Which of the following statements is true?

- A. The incidence of EAC and GERD decreased over the last 40 years.
- B. EAC is a risk factor for Barrett's esophagus.
- C. Patient's diet does not affect esophageal microbiome.
- D. Patients with BE have different microbiome than patients w/o BE.
- E. None of the above.

25. Which of the following statements is true?

- A. Patient's diet does not have any impact on esophageal microbiome.
- B. More acidic environment of distal esophagus may decrease incidence of EAC.
- C. Intestinal transformation of distal esophageal tissue is a risk factor for EAC.
- D. Patient's obesity does not have any impact on esophageal microbiome.
- E. None of the above.

26. The study concludes that:
- A. the change in microflora ultimately causes esophageal disease.
  - B. there is an association between the esophageal microbiome and several esophageal diseases.
  - C. acidic environment of distal esophagus does not affect its microflora.
  - D. patient's obesity does not have any impact on incidence of GERD.
  - E. None of the above.
27. Which of the following statements is true?
- A. The esophageal disease may lead to a change in its microflora.
  - B. There is a causal relationship between BE and EAC.
  - C. The esophageal intraluminal stasis may affect its microflora.
  - D. The change in esophageal microbiome may be associated with incidence of EAC.
  - E. All answers are correct.
28. Which of the following statements is NOT true?
- A. In BE normal tissue lining, the esophagus changes to tissue that resembles the lining of the intestine.
  - B. Obese patients have lower BMI than the lean ones.
  - C. The distinct patterns of microbiome might serve as a marker of early esophageal disease.
  - D. GERD is most likely associated with the change of esophageal microbiome.
  - E. The article points to possible association between GERD and EAC.
29. A drug administered to the patient has plasma biological half-life (the time required for the concentration of a substance in the plasma to decrease by half) of 20 minutes. What will be the plasma concentration of the drug after 1 hour if the concentration measured immediately after intravenous injection was 200 mg/L?
- A. 0.4 mg/L
  - B. 100 mg/L
  - C. 25 mg/L
  - D. 40 mg/L
  - E. 12.5 mg/L
30. Normal peripheral blood contains c.a. 5000 leukocytes/mm<sup>3</sup>. How many leukocytes is found in 1 drop of blood (0,15 ml)?
- A. 15 millions
  - B. 750 000
  - C. 150 000
  - D. 1.5 million
  - E. 75 000

**The text for questions no. 31 – 35.****Airborne particulate matter and human health: toxicological assessment and importance of size and composition of particles for oxidative damage and carcinogenic mechanisms.**

[Valavanidis A](#), et al. [J Environ Sci Health C Environ Carcinog Ecotoxicol Rev.](#) 2008 Oct-Dec;26(4):339-62.

Air pollution has been considered a hazard to human health. In the past decades, many studies highlighted the role of ambient airborne particulate matter (PM) as an important environmental pollutant for many different cardiopulmonary diseases and lung cancer. Numerous epidemiological studies in the past 30 years found a strong exposure-response relationship between PM for short-term effects (premature mortality, hospital admissions) and long-term or cumulative health effects (morbidity, lung cancer, cardiovascular and cardiopulmonary diseases, etc.). (...) Several independent groups of investigators have shown that the size of the airborne particles and their surface area determine the potential to elicit inflammatory injury, oxidative damage, and other biological effects. These effects are stronger for fine and ultrafine particles because they can penetrate deeper into the airways of the respiratory tract and can reach the alveoli in which 50% are retained in the lung parenchyma. Composition of the PM varies greatly and depends on many factors. The major components of PM are transition metals, ions (sulfate, nitrate), organic compounds, (...) and materials of biologic origin. Results from toxicological research have shown that PM have several mechanisms of adverse cellular effects, such as cytotoxicity through oxidative stress mechanisms, oxygen-free radical-generating activity, DNA oxidative damage, mutagenicity, and stimulation of proinflammatory factors. (...) In general, the evaluation of most of these studies shows that the smaller the size of PM, the higher the toxicity through mechanisms of oxidative stress and inflammation. (...) Vehicular exhaust particles are found to be most responsible for small-sized airborne PM air pollution in urban areas. (...).

31. Which of the following statements is NOT true?

- A. Air pollution has been considered a risk factor for various cardiopulmonary diseases.
- B. Ambient airborne particulate matter (PM) is an important environmental pollutant.
- C. PM exposure may cause short-term and long-term cumulative health effects.
- D. The composition of the PM varies greatly and depends on many factors.
- E. All answers are correct.

32. Which of the following statements is NOT true?

- A. PM surface area does not play a role in PM-dependent biological actions.
- B. The size of the airborne particles determines their potential to elicit biological effects.
- C. PM biological effects are stronger for fine and ultrafine particles.
- D. Vehicular exhaust particles represent major source of small-sized PM in urban areas.
- E. The answers B, C, and D are correct.

33. Which substance does NOT constitute a major component of PM?

- A. Carbon monoxide
- B. Transition metals
- C. Sulphates
- D. Organic compounds
- E. Materials of biologic origin

34. The toxic mechanism of action of PM may depend on:

- A. proinflammatory action.
- B. oxidative damage of cells.
- C. DNA damage.
- D. generation of various free radicals.
- E. All of the above.

35. Which of the following statements is NOT true?

- A. Vehicular exhaust particles can penetrate deep into the airways.
- B. Urban areas may be characterized by higher % of PM retained in lung parenchyma.
- C. The smaller the size of PM, the lower their toxicity.
- D. Vehicular exhaust particles show greater potential to elicit oxidative stress and inflammation.
- E. The surface area of mixture of ultrafine PM is greater than surface area of mixture of larger PM.

The text for questions no. 36 - 38

The total body water (TBW) constitutes 60% of the weight of the adult and is distributed among the following compartments (in % of body weight):

-Intracellular fluid (ICF, water inside the cells): 45%

-Extracellular fluid (ECF, water outside the cells): 15%

ECF is further subdivided into two types of fluids:

-Interstitial (the water bathing the cells in tissues): 10,5%

-Intravascular fluid (plasma) – 4,5%.

36. The body of a 70 kg adult contains:

- A. 30 kg of TBW
- B. 3150 g of plasma
- C. 15 kg of ECF
- D. 5 kg of interstitial fluid
- E. 50 kg of TBW

37. The ECF of the body of an 80 kg adult amounts to:

- A. 5 kg
- B. 7 kg
- C. 10 kg
- D. 12 kg
- E. 15 kg

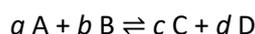
38. The distribution of a drug in body water compartments depends on many factors. Following intravenous administration, some drugs are distributed mainly in ECF. If the dose of such a drug is 100 mg, its concentration in plasma of a 70 kg patient will reach:
- 20 mg/l
  - 9.5 mg/l
  - 7 mg/l
  - 5 mg/l
  - 3.5 mg/l

## Chemistry

**Questions no. 39 – 41 refer to the following additional information - chemical equilibrium**

In a chemical reaction, chemical equilibrium is the state in which both reactants and products are present in concentrations having no further tendency to change with time. Therefore, no change in the properties of the system is observable. Usually, this state occurs when the rate of the forward reaction equals the rate of the backward reaction (but they are generally not zero). In other words, there is no net change in concentrations of reactants and products. This kind of equilibrium is also called a dynamic equilibrium.

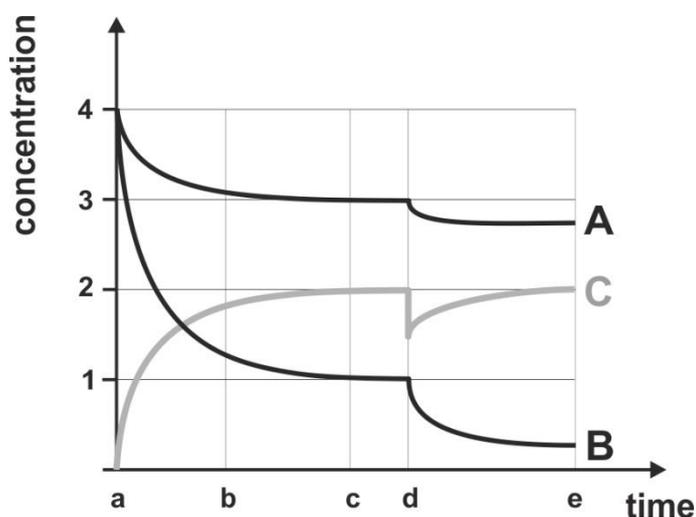
In the following chemical equation with arrows pointing both ways to indicate equilibrium, A and B are the reactants, C and D are the products, whereas  $a$ ,  $b$ ,  $c$ , and  $d$  are their respective stoichiometric coefficients:



The equilibrium constant,  $K_c$  is defined as:

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

where  $[A]$ ,  $[B]$ ,  $[C]$ , and  $[D]$  are unit-less molarities of particular compounds measured exactly in the equilibrium state. Note that the value of  $K_c$  is constant, as long as the temperature of reaction is constant. The possible exemplary changes in the concentrations of the reactants with time (kinetic curves) are shown in Fig. 8.

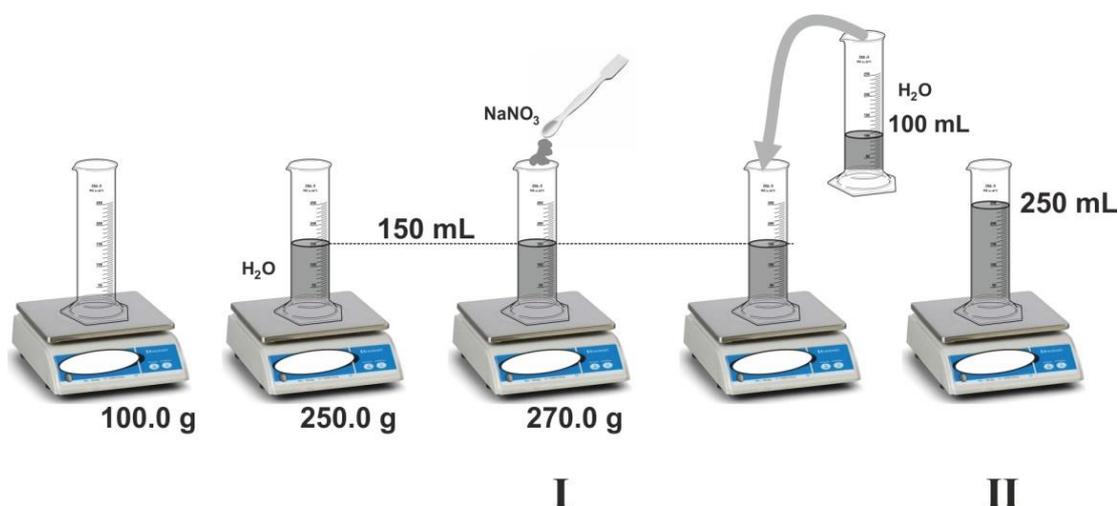


39. Based on the concentration profiles shown in Fig.8, indicate the periods of time, or points in time, when the reaction reaches equilibrium.
- Period of time a – b.
  - Period of time b – c.
  - Period of time c – d.
  - Point d.
  - Period of time d – e.
40. Choose the type of reaction for which the concentration profiles are illustrated in Fig. 8.
- $A + B \rightleftharpoons C$
  - $C \rightleftharpoons 2A + B$
  - $A + B \rightleftharpoons 2C$
  - $A + 3B \rightleftharpoons 2C$
  - $A + 3B \rightleftharpoons C$
41. Assuming that the equilibrium constant for the ammonia synthesis  $N_2 + 3H_2 \rightleftharpoons 2NH_3$  equals  $K_c = 1$ , in which direction will the reaction proceed when the composition of the reaction mixture is:  $[N_2] = 1 \text{ mol/dm}^3$ ,  $[H_2] = 2 \text{ mol/dm}^3$ ,  $[NH_3] = 3 \text{ mol/dm}^3$ ?
- Forward, toward synthesis of  $NH_3$ .
  - Backward, toward decomposition of the ammonia into the elements.
  - The reaction reached the equilibrium.
  - For the given composition, the reaction cannot proceed in any direction.
  - Cannot be judged based on the given data.

**Questions no. 42 – 45 refer to the following additional information**

The concentration of a solution is a measure of the amount of a solute that has been dissolved in a given amount of a solvent. The **percent concentration by mass**,  $c_p$ , (or weight percent, as it is sometimes called) is defined as the fraction of a solute in a solution multiplied by 100%. Another way of expressing concentration is **molarity**,  $c_m$ , (molar concentration). Molarity is expressed as the number of moles of a solute per one liter ( $1L = 1dm^3$ ) of a solution.

42. Which calculation should be used to determine the mass percent concentration of  $NaNO_3$  (solution II) prepared according to the following protocol:



- A.  $\frac{270.0-100.0}{270.0} * 100\%$ ,  
 B.  $\frac{270.0-250.0}{270.0-100.0+100.0} * 100\%$ ,  
 C.  $\frac{270.0-100.0}{270.0+100.0} * 100\%$ ,  
 D.  $\frac{270.0-250.0}{250.0} * 100\%$ ,  
 E.  $c_p$  cannot be calculated because the mass of the final solution is unknown.

43. What is the molarity of  $\text{NaNO}_3$  solution obtained in the stage I indicated in the figure above?

- A. 13.3 mol/L  
 B. 11.8 mol/L  
 C. 1.18 mol/L  
 D. 1.60 mol/L  
 E. 1.60 mol/mL

44. The reading on the screen of the balance in the stage II shown above is:

- A. 250.0 g  
 B. 270.0 g  
 C. 350.0 g  
 D. 370.0 g  
 E. dependent on density of water, which is not provided.

45. Fig. 9 presents a plot of change in  $\text{KNO}_3$  solubility in water with increasing temperature. This plot shows the concentration of the saturated solution expressed in g of  $\text{KNO}_3$  per 100 g of  $\text{H}_2\text{O}$ . Calculate the molarity of this solution at  $30^\circ\text{C}$  knowing that the density at this temperature equals  $1.25 \text{ g/cm}^3$ .

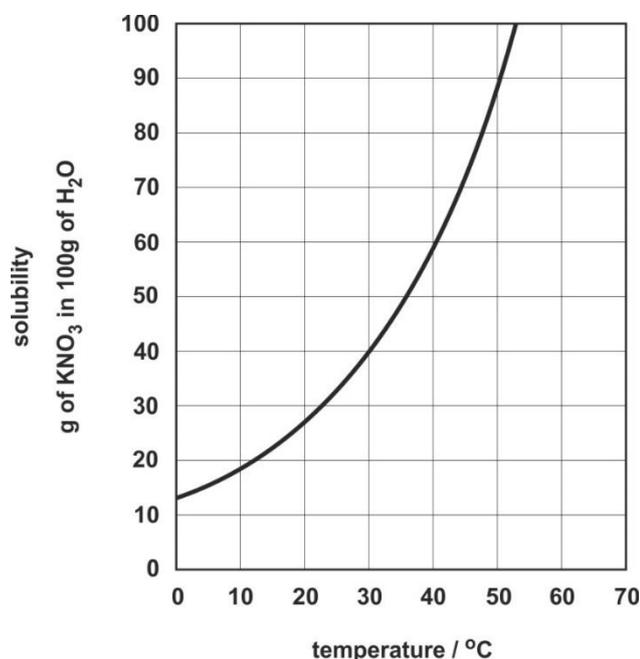


Fig. 9, Change in  $\text{KNO}_3$  solubility in water with increasing temperature

- A.  $12.4 \text{ mol/dm}^3$   
 B.  $5.0 \text{ mol/dm}^3$   
 C.  $4.0 \text{ mol/dm}^3$   
 D.  $3.6 \text{ mol/dm}^3$   
 E.  $1.8 \text{ mol/dm}^3$

46. pH of a certain aqueous solution is 8.5. Which of the following substances dissolved in water could be the solute?
- NaCl
  - H<sub>3</sub>PO<sub>4</sub>
  - C<sub>2</sub>H<sub>5</sub>OH
  - C<sub>6</sub>H<sub>5</sub>OH
  - CH<sub>3</sub>COONa
47. Which of the following are redox reactions?
- $C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$
  - $Na_2SO_4 + BaCl_2 = BaSO_4 + 2NaCl$
  - $Cr_2O_7^{2-} + 3SO_3^{2-} + 8H^+ = 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$
  - $H_2SO_4 + Cu(OH)_2 = CuSO_4 + 2H_2O$
  - $2H_2 + O_2 = 2H_2O$
- Only 3.
  - 2., 3., and 4.
  - 1., 4., and 5.
  - 3., 4., and 5.
  - 1., 3., and 5.
48. A student prepared five different solutions and placed them in five flasks numbered 1 through 5 but forgot to label the flasks. The prepared solutions are 0.5 M aqueous potassium chloride, 1 M sulfuric (VI) acid, 1 M acetic acid, 1 M aqueous sodium sulfate(VI), and 1 M aqueous sodium hydroxide. After some experiments, the following pieces of information were gathered:
- Flask 3 contains a solution with a pH higher than 4.9.
  - If H<sub>2</sub>SO<sub>4</sub> is added to the solution in flask 4, the product is the same as the solution in flask 2.
  - The solution in flask 5 is not of an organic compound.

Considering these data, indicate the chemical formula of the solutes contained in each flask.

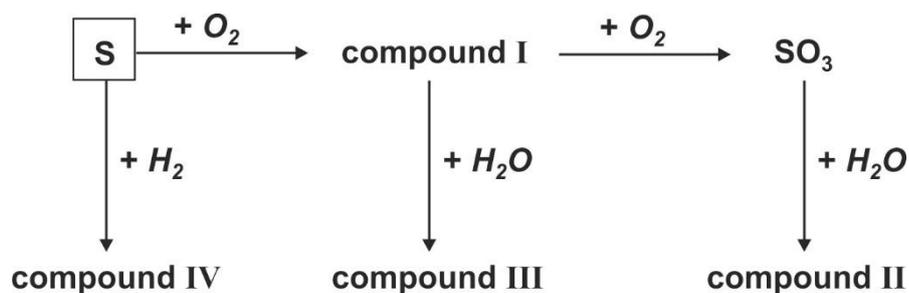
	1	2	3	4	5
A.	Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	CH <sub>3</sub> COOH	KCl	NaOH
B.	CH <sub>3</sub> COOH	Na <sub>2</sub> SO <sub>4</sub>	KCl	NaOH	H <sub>2</sub> SO <sub>4</sub>
C.	H <sub>2</sub> SO <sub>4</sub>	KCl	Na <sub>2</sub> SO <sub>4</sub>	NaOH	CH <sub>3</sub> COOH
D.	NaOH	Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	CH <sub>3</sub> COOH	KCl
E.	KCl	CH <sub>3</sub> COOH	NaOH	H <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>

49. Which combination of the aqueous solutions (each solution is 0.1 mol/dm<sup>3</sup>) could be used for preparing a buffer of the pH slightly smaller than 7.0?
- HCl and NaOH
  - Na<sub>3</sub>PO<sub>4</sub> and KOH
  - H<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub>
  - CH<sub>3</sub>COOH and NH<sub>4</sub>Cl
  - NH<sub>3</sub> and NH<sub>4</sub>Cl

50. At 40 °C, compound X is a liquid, compound Y is a gas, and compound Z is a solid. The single set of melting points (in kelvins) of these compounds could be:

	X	Y	Z
A.	303	323	373
B.	323	298	273
C.	273	298	323
D.	313	323	473
E.	303	198	298

51. For the given balanced reaction  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ , what was the mass of the burnt glucose if 44 g of  $CO_2$  was produced ?
- A. 30 g  
B. 60 g  
C. 90 g  
D. 120 g  
E. 180 g
52. The ideal gas mixture of two gases contains: 5 moles of  $N_2$  and 15 moles of  $O_2$ . If the pressure in the container is 40 atm, the pressure exerted by  $N_2$  is:
- A. 50 atm  
B. 40 atm  
C. 30 atm  
D. 20 atm  
E. 10 atm
53. The scheme below presents typical chemical reactions of sulfur (S) and its compounds. What are the compounds I, II, III, and IV?



- A. I =  $SO_2$ , II =  $H_2SO_4$ , III =  $H_2SO_3$ , IV =  $H_2S$   
 B. I =  $SO$ , II =  $H_2SO_4$ , III =  $H_2SO_3$ , IV =  $H_2S$   
 C. I =  $SO_2$ , II =  $H_2S_2O_3$ , III =  $H_2SO_4$ , IV =  $H_2S$   
 D. I =  $SO_3$ , II =  $H_2SO_4$ , III =  $H_2SO_4$ , IV =  $H_2S$   
 E. I =  $SO_2$ , II =  $H_2SO_4$ , III =  $H_2SO_3$ , IV =  $H_2S_2O_3$

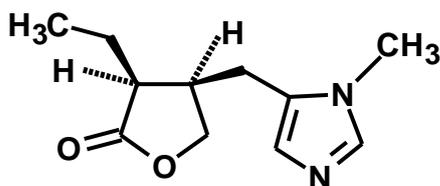
54. Assume that you are a physician administering a drug in a solution containing 5.0 mg of drug/L of a solution. If the recommended dosage of the drug is  $3.5 \times 10^6$  g per kilogram of body weight, what volume of the solution would you prescribe daily for a 70 kg patient?
- 33 mL
  - 98 mL
  - 54 mL
  - 25 mL
  - 49 mL
55. 25.0 g of a liquid that has a density of 1.25 g/mL needs to be measured out in a graduated cylinder. What volume should be used? (note, 1 mL = 1 cm<sup>3</sup>)
- 50.0 mL
  - 31.3 cm<sup>3</sup>
  - 20.0 cm<sup>3</sup>
  - 25.0 mL
  - 5.00 cm<sup>3</sup>
56. Element E has the electron structure 2(K) 8(L) 5(M). Which of the following statements about this element is/are correct?
- The element E is in Group 15, Period 3 of the Periodic Table.
  - The atomic mass of the element E is 15.
  - The element E forms hydroxides.
  - The element E forms acids.
  - The highest possible valence of E is +V.
- Only 1.
  - 1, 4, and 5.
  - 1, 2, and 3.
  - 1 and 2.
  - 1, 3, 4, and 5.
57. Sodium chloride (table salt) is composed of sodium (1 valence electron) and chlorine (7 valence electrons). This is an example of what type of bonding?
- Covalent
  - Metallic
  - Polar covalent
  - Ionic
  - None of the above.

58. There are four test tubes filled with equal volumes of the following aqueous solutions:  $\text{AgNO}_3$  (1 M),  $\text{Na}_2\text{S}$  (0.2 M),  $\text{BaCl}_2$  (0.1 M), and  $\text{NiCl}_2$  (0.1 M). All of the solutions were mixed in a beaker. What salts will precipitate? Key part of the solubility chart is provided below

anion cation	$\text{Cl}^-$	$\text{NO}_3^-$	$\text{CO}_3^{2-}$	$\text{SO}_4^{2-}$	$\text{S}^{2-}$	$\text{C}_2\text{O}_4^{2-}$
$\text{Na}^+$						
$\text{Ag}^+$	↓		↓		↓	↓
$\text{Ni}^{2+}$			↓		↓	
$\text{Ba}^{2+}$			↓	↓		↓
$\text{Ca}^{2+}$			↓			↓

↓ - insoluble precipitate

- A. Only  $\text{AgCl}$   
 B. Only  $\text{Ag}_2\text{S}$   
 C. Only  $\text{NiS}$   
 D.  $\text{AgCl}$ ,  $\text{Ag}_2\text{S}$ ,  $\text{NiS}$   
 E.  $\text{NiS}$ ,  $\text{Ba}(\text{NO}_3)_2$ ,  $\text{AgCl}$
59. The Pilocarpine, an alkaloid found e.g. in South American plant *Pilocarpus*, is a medicine used to reduce the pressure inside the eye (<https://en.wikipedia.org/wiki/Pilocarpine>)

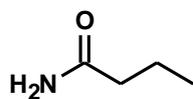


This is its line-angle (skeleton) formula. Choose the correct molecular formula of Pilocarpine, assuming that in this mode of presentation carbon atoms appear at the end of each segment, and all carbon atoms are connected with the number of hidden hydrogen atoms corresponding to their valence\*

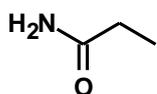
\*Valence is the property of an element that determines the number of other atoms with which an atom of the element can combine; hydrogen and halogens are usually monovalent, oxygen and sulphur divalent, nitrogen and phosphorus trivalent, and carbon tetravalent.

- A.  $\text{C}_{11}\text{H}_{14}\text{N}_2\text{O}_2$   
 B.  $\text{C}_{11}\text{H}_{16}\text{N}_2\text{O}$   
 C.  $\text{C}_{11}\text{H}_{16}\text{N}_2\text{O}_2$   
 D.  $\text{C}_{11}\text{H}_{16}\text{NO}_2$   
 E.  $\text{C}_{10}\text{H}_{16}\text{N}_2\text{O}_2$
60. What is the correct number of atoms with certain valence in Pilocarpine?
- A. 14 monovalent, 2 divalent, 2 trivalent and 11 of tetravalent atoms  
 B. 16 monovalent, 1 divalent, 2 trivalent and 11 of tetravalent atoms  
 C. 16 monovalent, 2 divalent, 1 trivalent and 11 of tetravalent atoms  
 D. 16 monovalent, 2 divalent, 2 trivalent and 11 of tetravalent atoms  
 E. 16 monovalent, 2 divalent, 2 trivalent and 10 of tetravalent atoms

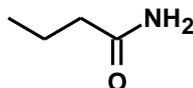
61. Chemists organize the organic compounds in groups called the homologous series. Members of these series differ by  $-\text{CH}_2-$  (methylene) group, and usually have similar chemical properties, but their physical properties change in proportion to the number of atoms in the molecule. Which of the following compounds presented below form a homologous series?



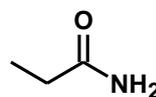
1.



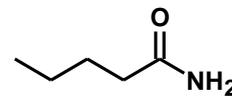
2.



3.



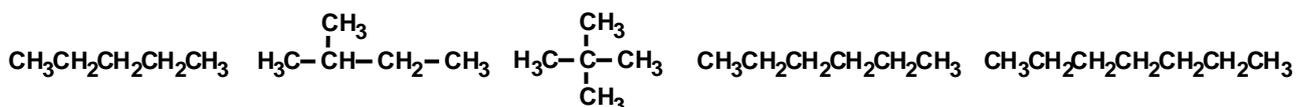
4.



5.

- A. 1., 2., and 3.  
 B. 2., 3., and 4.  
 C. 2., 3., and 5.  
 D. 1., 3., and 5.  
 E. 2., 4., and 5

62. The bulk physical properties of the compound usually depend strongly on the structure of its molecules. The distance between particular atoms in the molecule is essential. More compact molecules (those with the branched chain) are usually more volatile, due to a lower boiling point. Below, the boiling points of some hydrocarbons are arranged in a growing order:  
 $9.5^\circ\text{C} - 10^\circ\text{C} < 27.8^\circ\text{C} < 35.9 - 36.3^\circ\text{C} < 68.5 - 69.1^\circ\text{C} < 98.3^\circ\text{C}$   
 and the corresponding hydrocarbons are shown at random. Indicate the sequence of hydrocarbons arranged by their boiling points starting from the lowest.



1.

2.

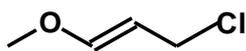
3.

4.

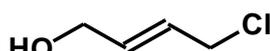
5.

- A.  $2. < 4. < 3. < 5. < 1.$   
 B.  $3. < 2. < 1. < 4. < 5.$   
 C.  $4. < 1. < 2. < 5. < 3.$   
 D.  $5. < 2. < 4. < 3. < 1.$   
 E.  $1. < 2. < 3. < 4. < 5.$

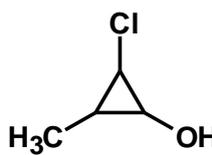
63. Isomers of organic compounds have the same molecular formula (composition) but a different way of bonding atoms with each other. Which of the following compounds IS NOT an isomer of all the others?



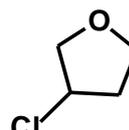
1.



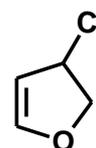
2.



3.



4.



5.

- A. 1.
- B. 2.
- C. 3.
- D. 4.
- E. 5.

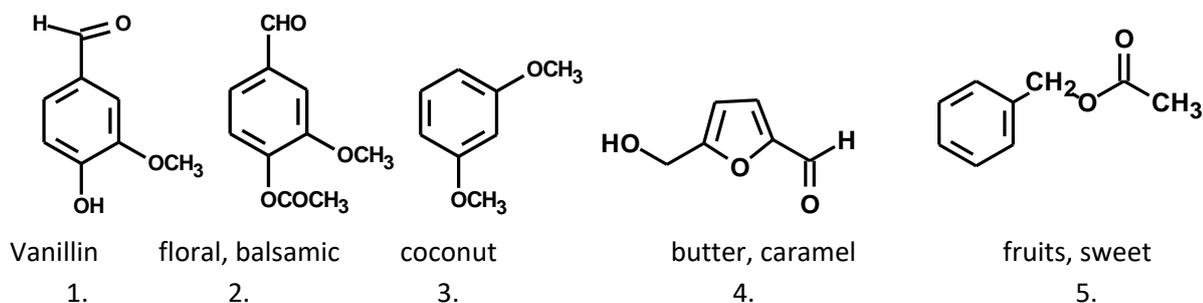
The elements of unsaturation are very useful in a structure elucidation of organic compounds. The element of unsaturation  $S$  can be derived from molecular formula of a compound in the following manner:

$$S = \frac{2 + 2x(I) + 1xm(III) - 1xn(I)}{2}$$

Where  $l$  is a number of tetravalent atoms,  $m$  is a number of trivalent atoms, and  $n$  is a number of monovalent (usually hydrogen or halogens) atoms.

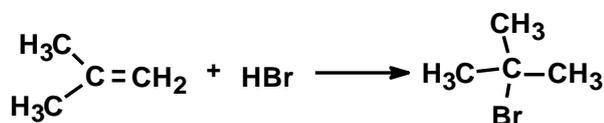
What does the element of unsaturation mean in practice? One  $S$  is either a double bond (between carbon atoms or e.g. between carbon and oxygen) or a ring, a triple bond = two elements of unsaturation.

64. Which of the following fragrances have the lowest value of element of unsaturation?



- A. 1. and 2.
- B. 1. and 3.
- C. 3. and 4.
- D. 4. and 5.
- E. 2. and 5.

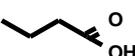
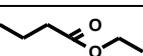
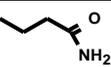
65. What type of reaction is represented by the following scheme?



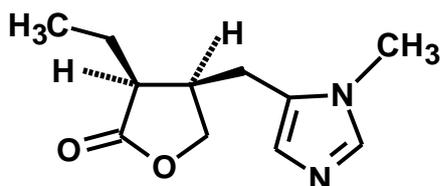
- A. Condensation
- B. Elimination
- C. Addition
- D. Substitution
- E. Oxidation



Chemical properties of organic compounds depend on the presence of functional groups. The most important of them are listed below together with the characteristic endings of the names of compounds containing them:

Functional group	Class of compound	Examples	The ending in the name
Hydroxyl -OH	Alcohols, phenols		-ol
-O-	Ethers		ether
Amino -NH <sub>2</sub> (R)	Amines		-amine
Carbonyl C=O	Aldehydes		-al
Carbonyl	Ketones		-on
Carboxyl -COOH	Carboxylic acids		-oic acid
Ester -COOR	Esters		alkyl alkanoate
Amide -CONH <sub>2</sub> (R)	Amides		-amide

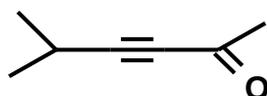
68. What series of functional groups is present in Pilocarpine?



- A. Carboxyl, amino
- B. Ester, amino
- C. Carbonyl, carboxyl
- D. Amino, carbonyl
- E. Ether, amino

There are many organic compounds that possess more than one functional group. In such case, the problem of preference in naming arises. Generally, the more oxidized functional groups are preferred in naming. The current preference of certain classes of compounds in naming is as follows: acid > ester > aldehyde > ketone > alcohol > amine > alkene > alkyne > alkane > ether > halogen derivatives

69. The correct name of the following compound is:



- A. 5-methylhex-3-yn-2-on
- B. 2-methylhex-3-yn-5-on
- C. 5-methylhex-3-yhnj-2-al
- D. 5-methylhex-2-on-3-yn
- E. 1-isopropylbut-1-yn-3-on

**Questions no. 70 – 72 refer to the following information**

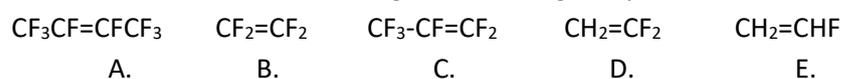
Read the following excerpt carefully and answer the questions pertaining to it:

In recent years, amid stories about plastic waste ending up on beaches and even in our diets, public opinion has started to turn against plastics. What was once considered a wonder material that was cheap, light, and clean is now being seen by many as a serious environmental problem. That shift in opinion has led some universities to rethink plastic-use policies, with much of the drive for change coming from younger members of the research community. In the UK, the University of Leeds is one of several universities that have made an ambitious pledge to completely cut out single use plastic. But while alternatives to plastic cups and cutlery can be found, replacing single-use items in the lab is not always so simple. For example, replacing plastic petri dishes for cell culture with glass ones might seem like a sensible switch, but the cost of using glass dishes are around 30 times as much as those of plastic ones, making it cost prohibitive for labs that use a lot of them. (Can Laboratories Move Away from Single-Use Plastic? L. Howes, *ACS Cent. Sci.* 2019, **5**, 1904-190)

70. Why is coming back to glass items in laboratory not so simple? (Choose the main reason for this conclusion.)
- A. Because it is a question of university policies.
  - B. Because it increases the costs of laboratory procedures enormously.
  - C. Because plastic is light.
  - D. Because plastic is clean.
  - E. Because public opinion is against it.
71. Why has the public opinion started to turn against plastic? (Choose the main reason.)
- A. Because it is clean and light material.
  - B. Because plastic waste can be found on beaches.
  - C. Because it is cheap.
  - D. Because plastic can be found in food.
  - E. Because it can lead to many environmental problems.
72. Based on the text, name a proponent of completely cutting out single use plastic:
- A. public opinion
  - B. younger members of research community
  - C. the UK government
  - D. the University of Leeds
  - E. journalists

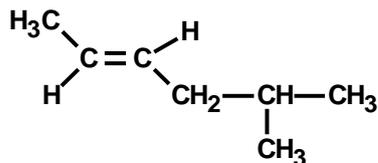
Polymers are important applied organic compounds contributing to one of the main branches of the chemical industry. They are macromolecules formed from single molecules (monomers), usually by addition or condensation.

73. Polytetrafluoroethylene (systematic name polytetrafluoroethene), PTFE, Teflon can be found in everyday items, such as nonstick pans, weather-proof clothing, and insulators for electronics. Indicate its monomer among the following compounds:

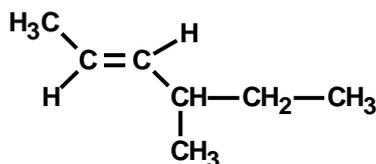




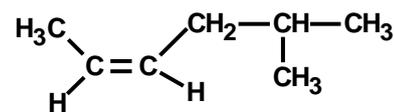
The structural formulas of some organic compounds are presented below:



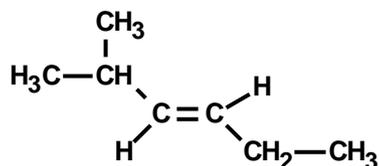
1.



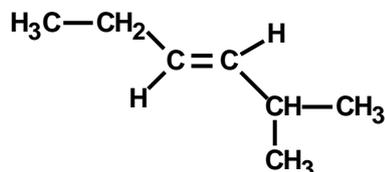
2.



3.



4.



5.

77. Which of them are structural isomers?

- A. 1. and 2.
- B. 1. and 5.
- C. 4. and 5.
- D. 2. and 5.
- E. Answers A., B., and D. are correct

78. Which of them depict identical stereoisomers?

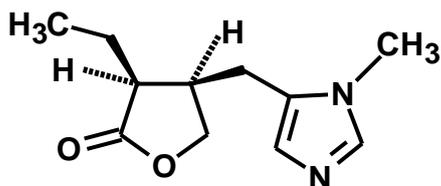
- A. 1. and 2.
- B. 4. and 5.
- C. 1. and 3.
- D. 3. and 4.
- E. 3. and 5.

79. Which of them form a pair of different stereoisomers?

- A. 4. and 5.
- B. 2. and 3.
- C. 3. and 5.
- D. 1. and 3.
- E. Answers A and C are correct.

In the case of optically active compounds (Pilocarpine is the one) that are chiral i.e. their forms are as an object and its mirror image (enantiomers), which is due to the presence of a stereogenic centre (or more of them). A stereogenic centre (chiral atom) is a carbon atom with four different substituents (also when it constitutes a part of a ring).

80. How many stereogenic centres are present in the following Pilocarpine molecule?



- A. None
- B. One
- C. Two
- D. Three
- E. Four

Logic

Read the following passage and answer the questions.

### Oral health, general health and quality of life

Severe caries detracts from children's quality of life: they experience pain, discomfort, disfigurement, acute and chronic infections, and eating and sleep disruption as well as higher risk of hospitalization, high treatment costs and loss of school days with the consequently diminished ability to learn. Caries affects nutrition, growth, and weight gain. Children of three years of age with nursing caries weighed about 1 kg less than control children because toothache and infection alter eating and sleeping habits, dietary intake, and metabolic processes.

Ninety per cent of pre-adolescents reported an impact related to oral health. Prevalence of dental pain was found to be about 33% among Brazilian teenagers, of whom 9% reported distressing, excruciating pain. Toothache leads to school absence, which is a ready indicator of children's health. In the USA, where caries is lower than elsewhere, visits or dental problems accounted for 117 000 hours of school lost per 100 000 children.

<https://www.who.int/bulletin/volumes/83/9/editorial30905html/en/>

81. Choose whether the following statements are true (T) or false (F).
- A. Children with caries in permanent teeth on average have lower weight than children without caries. True    False
  - B. In Brazil, 9% of teenagers reported excruciating pain. True    False
  - C. In the USA, the prevalence of caries is lowest as compared to other countries. True    False
  - D. In the USA, it was estimated that every child lost more than one school hour because of dental problems. True    False
  - E. Ninety percent of adolescents have not reported any dental problems. True    False
  - F. Among others, caries can influence children's eating behaviors, and cause sleep problems, as well as lead to loss of school days. True    False

82. The Gardeners' Society published the Report for the year 2019. The Report indicates that: 60% of apples collected were heavy (over 0.1 kg), 10% of apples were green, 80% were red, and 50% were big (having a diameter of over 7 cm). Which of the following statements is false?

- A. All red apples weren't big.
- B. 40% of red apples were big.
- C. There were no apples that were both green and big.
- D. Half of the apples were small.
- E. All green apples were heavy.

**The following text refers to questions no. 83 - 84**

Five runners took part in the finals of the SPINGER RUN: Ben, Gavin, Olaf, Robin, and Will. Based on the pieces of information provided below, answer the following questions:

- Ben was neither the first nor the last person in this final.
- Gavin was faster than Olaf, but slower than Will.
- Olaf discovered that there were equally many runners who were faster and slower than him.

83. The winner of SPRINGER RUN was:

- A. Ben
- B. Gavin
- C. Olaf
- D. Robin
- E. Will

84. The last two runners (4<sup>th</sup> and 5<sup>th</sup>) were:

- A. Gavin and Ben
- B. Ben and Robin
- C. Ben and Will
- D. Will and Gavin
- E. Ben and Olaf

85. Indicate the number completing the sequence: 22, 19, 26, 23, 30, 27, 34, 31, .....

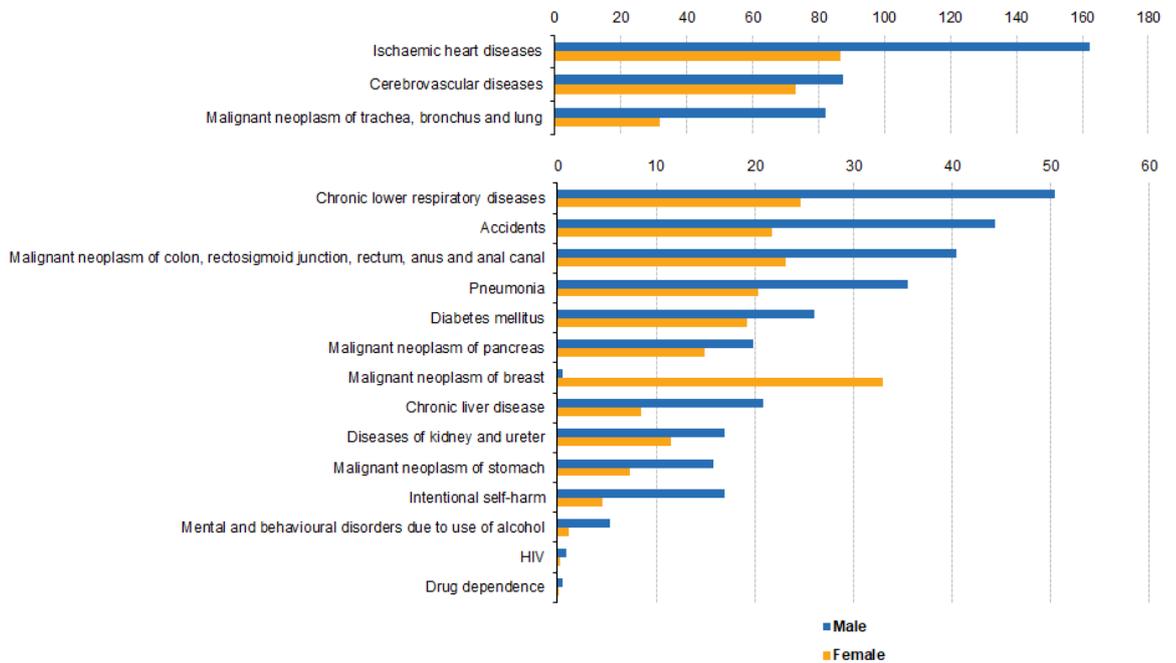
- A. 24
- B. 28
- C. 32
- D. 38
- E. 44

86. Indicate the number completing the sequence: 23, 25, 29, 37, 53, 85, ...

- A. 93
- B. 99
- C. 117
- D. 149
- E. 170

The figure below illustrates the causes of mortality in European Union in 2016. “Standardized” means that this rate is not contingent on the age of the population.

**Causes of death — standardised death rate, EU-28, 2016**  
(per 100 000 inhabitants)



Note: the figure is ranked on the average of male and female. Note the difference in the scales employed between the two parts of the figure.

Source: Eurostat (online data code: hlth\_cd\_asdr2)



[https://ec.europa.eu/eurostat/statistics-explained/images/0/0e/Causes\\_of\\_death\\_%E2%80%94\\_standardised\\_death\\_rate%2C\\_EU-28%2C\\_2016\\_%28per\\_100\\_000\\_inhabitants%29\\_HLTH19.png](https://ec.europa.eu/eurostat/statistics-explained/images/0/0e/Causes_of_death_%E2%80%94_standardised_death_rate%2C_EU-28%2C_2016_%28per_100_000_inhabitants%29_HLTH19.png)

87. Which of the following can be concluded from the graph above?

- A. In each of 28 European countries included in this analysis, the highest mortality is related to ischaemic heart diseases.
- B. The breast cancer was the cause of most deaths among women in EU-28 in 2016.
- C. There were no deaths because of malignant neoplasms of breast among males in EU-28.
- D. Most of the deaths in EU-28 in 2016 occurred because of lung and trachea malignant neoplasms.
- E. Cerebrovascular disease is the second most common cause of death in both males and females.

88. If some students like peaches and there are no adolescents that aren't students, then which of the statements is always true?

- A. There is not one adolescent that does not like peaches.
- B. Anybody who likes peaches is an adolescent.
- C. All adolescents like peaches.
- D. All students are adolescents.
- E. None of the above.

89. A wise man hid a treasure box on Sunny Island. He prepared a description of how to get to its location starting from the cottage in the middle of Island. The instruction is: "Walk 2 km East, then turn left and walk for 1 km, next turn right and walk for 1 km, turn South and walk for 2 km and next turn right and walk for 4 km. There it is!!!! The treasure is hidden in the big box below an enormous stone." In which direction relative to the cottage is the treasure hidden?

- F. East
- G. South
- H. North-East
- I. South-East
- J. South-West

90. Which of the assumptions is/are implicit in the notice:

"Do not enter the Doctor's office without call".

Assumptions:

- I. It is possible to enter Doctor's office.
- II. Such warning will have some effect.

- A. Only assumption I is implicit.
- B. Only assumption II is implicit.
- C. Either I or II is implicit.
- D. Neither I nor II is implicit.
- E. Both I and II are implicit.

91. Decide which conclusion can be driven from the statement below.

Statement:

"Nothing in life is to be feared, it is only to be understood." (by Marie Curie-Skłodowska)

Conclusion:

- A. Everything in life is to be simple.
- B. If you understood something, you need to fear it.
- C. There are things in life that we can be afraid of because we do not understand them.
- D. There are some things that person can be afraid of.
- E. Everything can be understood.

**THE KEY**

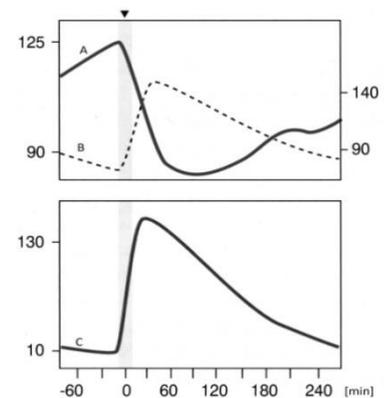
1. T; B T; C F; D F; E F; 2. E; 3. C; 4. A; 5. B; 6. A; 7. D; 8. A; 9. D; 10. A; 11. C; 12. A; 13. A; 14. A; 15. B; 16. C; 17. B; 18. B; 19. D; 20. B; 21. B; 22. A; 23. A; 24. D; 25. C; 26. B; 27. E; 28. B; 29. C; 30. B; 31. E; 32. A; 33. A; 34. E; 35. C; 36. B; 37. D; 38. B; 39. C; 40. D; 41. B; 42. B; 43. D; 44. D; 45. D; 46. E; 47. E; 48. B; 49. C; 50. C; 51. A; 52. E; 53. A; 54. E; 55. C; 56. B; 57. D; 58. D; 59. C; 60. D; 61. C; 62. B; 63. E; 64. C; 65. C; 66. E; 67. C; 68. B; 69. A; 70. B; 71. E; 72. D; 73. B; 74. A; 75. A; 76. D; 77. E; 78. B; 79. D; 80. C 81. A F; B F; C T; D F; E F; F T; 82. A; 83. E; 84. B; 85. D; 86. D; 87. E; 88. E; 89. E; 90. E; 91. C;

**Reasoning and Critical Thinking in Pre-medical Sciences 2019 Test**

1. Insulin is a protein used to treat millions of diabetic patients so there is a high demand for it. Historically, it was extracted from pancreata of slaughter animals. However, now, genetic engineering is used for the large-scale production of human insulin. Which of the statements below correctly describes this process?
  - A. Isolating insulin from human blood and introducing it into the DNA of a bacterium. As the bacterium reproduces, it produces large quantities of insulin DNA that can be used to treat human diabetes.
  - B. Isolating insulin from human blood and introducing it into the DNA of a bacterium. As the bacterium reproduces, it produces large quantities of insulin that can be used to treat human diabetes.
  - C. Isolating the insulin gene from a human chromosome and replacing it in another chromosome in the same human, so that it will work better to produce large quantities of insulin.
  - D. Isolating the insulin gene from a human chromosome and inserting it into the DNA of a bacterium. As the bacterium reproduces, it produces large quantities of insulin that can be used to treat human diabetes.
  - E. Isolating the insulin gene from a human chromosome and inserting it into the DNA of a bacterium. As the bacterium reproduces, it produces large quantities of insulin DNA that can be used to treat human diabetes.

2. Fig. 1 shows changes in blood concentration of three substances (A, B, C) after a meal taken at time 0. These substances are respectively:

A	insulin	glucose	glucagon
B.	glucose	glucagon	insulin
C.	glucagon	glucose	insulin
D.	insulin	glucagon	glucose
E.	glucose	insulin	glucagon



**Fig. 1**

3. Neurons require large amounts of energy. Any disturbance in the function of these cells can have serious consequences. For example, a loss of oxygen supply to the brain causes unconsciousness within 5–10 seconds. Which of the following statements are true?
  1. Neurons in the brain are capable of relying on anaerobic respiration for long periods of time.
  2. The homeostatic systems of the body will constantly have to work to resist temperature increases in the brain.
  3. An overdose of insulin in the body could cause a serious loss of brain function, such as inducing a coma.
  4. During normal functioning of neurons in the brain, high levels of carbon dioxide could be produced.
  - A. 1. and 2.
  - B. 1. and 3.
  - C. 2. and 3.
  - D. 1., 2. and 4.
  - E. 2., 3. and 4.

4. Type 2 diabetes usually affects people over 40. Initially, they have a higher level of insulin than healthy people. This information indicates that the underlying cause of the disease can be:
- genetically determined over-secretion of insulin.
  - decreased responsiveness of target cells to insulin.
  - destruction of cells secreting insulin.
  - excessive ingestion of carbohydrates.
  - sedentary lifestyle and obesity.

5. Four substances are present in each of the two animal cells, 1 and 2, the membranes of which are in contact. The table presents their concentrations in arbitrary units. Transport of which substance between these two cells, if generally possible, would require energy?

- E: cell 2 → cell 1
- F: cell 1 → cell 2
- G: cell 2 → cell 1
- H: cell 1 → cell 2
- G: cell 1 → cell 2

substance	concentration in arbitrary units	
	cell 1	cell 2
E.	9	15
F.	12	8
G.	7	4
H.	6	3

6. The name of a hormone *atrial natriuretic peptide* conveys information that it is synthesized in A, affects the balance of B, and has something to do with C.

	A	B	C
A.	brain	calcium	urine
B.	pulmonary alveolus	potassium	urea
C.	heart	potassium	uterus
D.	heart	sodium	urine
E.	blood vessels	sodium	urea

7. Polydactyly (having extra fingers or toes), when occurring by itself, is associated with autosomal dominant mutations in a single gene. Penetrance of this gene is estimated at 80%. What is the probability of having a child with polydactyly when one parent is heterozygous and the other is normal with respect to this trait?
- 0%
  - 25%
  - 40%
  - 50%
  - 100%

**The following text refers to questions 8-10**

Secretion of thyroid hormones is regulated by the hypothalamic-pituitary-thyroid axis. The hypothalamus senses circulating levels of thyroid hormone thyroxin and respond to its low levels by releasing thyrotropin-releasing hormone (TRH). The TRH stimulates the anterior pituitary to produce thyroid-stimulating hormone (TSH). The TSH, in turn, stimulates growth of the thyroid gland and thyroxin secretion. Thyroxin exerts negative feedback control over the hypothalamus as well as anterior pituitary, thus controlling the release of both TRH from the hypothalamus and TSH from the anterior pituitary gland. Thyroid hormones need dietary iodine to be synthesized and they stimulate metabolism.

Consider three patients visiting an endocrinologist:

8. The first one is an adult that has recently developed an enlarged thyroid gland (goiter) and low thyroxine levels. He complains of mental sluggishness, physical lethargy, lack of appetite, and difficulty with keeping warm. These are all symptoms of too little thyroid hormone (hypothyroidism). In this case the most likely cause would be:
- hyposecretion of TSH from the pituitary.
  - hyposecretion of thyroxine due to dietary iodine deficiency.
  - genetically determined inability to synthesize thyroxine.
  - defect in the hypothalamus resulting in the inability to secrete TRH.
  - defective receptors for thyroxine in all body cells.
9. The second patient has low plasma concentrations of both thyroxine and TSH, and identical symptoms as the previous one. What test might be performed to determine which gland(s) is/are at fault in this case?
- Oral supplementation of thyroxine and follow-up of symptoms
  - Injection of TRH; if blood levels of TSH and thyroxin rise, it means that the hypothalamus is not secreting enough TRH.
  - Injection of TRH; if blood levels of TSH rise, but that of thyroxin do not, the defect is at the level of the hypothalamus, and the other at the level of the thyroid.
  - Injection of TRH; if neither TSH nor thyroxin levels rise, the defect is at the level of the pituitary.
  - B, C and D are correct answers.
10. The third patient is an infant with growth and mental retardation indicating hypothyroidism but with high level of thyroxine. The most likely diagnosis would be:
- pituitary tumor over-secreting TSH.
  - hyposecretion of thyroxine due to dietary iodine deficiency.
  - genetically determined inability to synthesize thyroxine.
  - defect at the level of the hypothalamus resulting in the inability to secrete TRH.
  - genetically determined defect in cellular receptors for thyroxine.
11. Myasthenia gravis is an autoimmune disease in which the body's immune system attacks the acetylcholine receptors on the motor end plate in skeletal muscles leading to muscle weakness. Normal function of the neuromuscular junction can be disrupted by various agents. The drug curare binds to acetylcholine receptors on the motor end plate, but does not activate them inducing paralysis. Botulinum toxin does the same by blocking acetylcholine release from the nerve endings. Organophosphate "nerve gases" act by inhibiting the function of the acetylcholinesterase. Acetylcholine thus builds up and continues to act so that any nerve impulses are continually transmitted and muscle contractions do not stop. Which of these compounds (or their congeners) might be useful as a treatment for myasthenia gravis?
- curare
  - botulinum toxin
  - acetylcholinesterase inhibitors
  - curare and botulinum toxin
  - none of the above
12. Patients suffering from chronic myeloid leukemia (CML) have the Philadelphia chromosome mutation which results in the formation of the hyperactive *bcr-abl* protein. Imatinib, the drug that revolutionized treatment of CML, was invented in the late 1990s by rational drug design. What may *rational drug design* mean in this context?
- Design of molecules that are complementary in shape and charge to the biomolecular target with which they interact, and therefore will bind and activate it.
  - Finding a molecule that will prevent particular cancer cells from proliferating.
  - Design of molecules that are complementary in shape and charge to the biomolecular target with which they interact, and therefore will bind and inactivate it.
  - Procedure of finding a molecule acting on a particular target only with computer simulations, what allows to bypass animal testing.
  - Procedure of finding molecules acting in a particular disease and testing their potency on laboratory animals.

13. The currently accepted estimated average requirement (EAR) for vitamin A is 625 µg per day. What conclusion can be drawn from this information?
- A. 5% of the population require more than 625 µg of vitamin A per day.
  - B. 10% of the population require more than 625 µg of vitamin A per day.
  - C. 25% of the population require more than 625 µg of vitamin A per day.
  - D. 50% of the population require more than 625 µg of vitamin A per day.
  - E. 95% of the population require more than 625 µg of vitamin A per day.
14. A patient with leukemia is being treated with chemotherapy and radiotherapy. The patient is found to have a low blood platelet count, and a high percentage of the white blood cells is abnormal. However, the hemoglobin level was within normal limits. Which row of the table shows this patient's symptoms?

	disease resistance	oxygen transport	blood clotting
A.	low	low	low
B.	high	low	high
C.	low	normal	low
D.	low	low	normal
E.	normal	normal	high

15. Vasopressin or antidiuretic hormone (ADH) is produced by neurons in the hypothalamus, released from their axons to the blood in the pituitary gland, and has receptors in the kidneys. ADH leaves the brain by the jugular vein. In what order must it travel through the blood vessels listed below to reach its target?

1. aorta, 2. pulmonary artery, 3. pulmonary vein, 4. renal artery, 5. vena cava

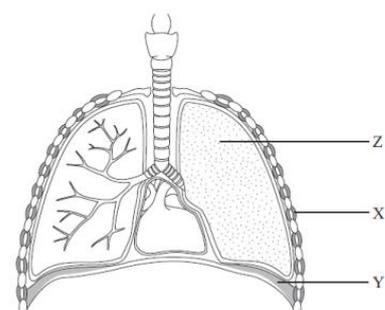
- A. 1., 2., 3., 4., 5.
- B. 2., 3., 1., 4., 5.
- C. 5., 2., 3., 1., 4.
- D. 3., 2., 1., 5., 4.
- E. 5., 3., 2., 1., 4.

16. The volume of urine is adjusted to the current status of water balance mainly by the level of circulating ADH. Water loss (e.g. through perspiration) causes a change sensed by osmoreceptors in the hypothalamus and more ADH is released. This increases water retention by the collecting duct cells in nephrons to restore homeostasis. Which sequence of events is correct in case of dehydration?

	blood osmotic pressure	ADH release	collecting duct function	urine concentration
A.	low	decreases	less water reabsorbed	low
B.	high	increases	more water reabsorbed	high
C.	low	increases	less water reabsorbed	low
D.	high	decreases	more water reabsorbed	high
E.	low	decreases	more water reabsorbed	high

17. Lung ventilation follows the Boyle's law, which states that the pressure of a gas is inversely proportional to the volume it occupies. Moreover, gas moves from areas of higher pressure to those of lower pressure. What happens to the muscles indicated by X and Y, and the pressure in Z during inspiration?

	muscle X	muscle Y	pressure in Z
A.	relax	contract	increases
B.	contract	contract	decreases
C.	contract	relax	increases
D.	relax	relax	decreases
E.	relax	contract	decreases

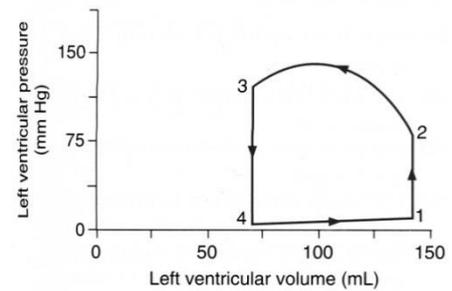


18. In normal adults, the outputs of both ventricles are equal in the steady state. In which of the following cases is pulmonary blood flow greater than aortic blood flow?

- A. Fetus
- B. Left to right ventricular shunt
- C. Right to left ventricular shunt
- D. Right ventricular failure
- E. Sleep

19. A single cycle of contraction, ejection, relaxation and refilling of the left ventricle of a human heart can be visualized in the form of pressure-volume loop as shown in Fig. 2. One phase of the cycle is called isovolumetric contraction and it occurs during ventricular systole before the aortic valve opens. Ventricular pressure increases, but volume remains constant because blood cannot be ejected into the aorta against a closed valve. On the graph, this phase occurs from point:

- A. 4. → 1.
- B. 1. → 2.
- C. 2. → 3.
- D. 3. → 4.
- E. 4. → 2.



**Fig. 2**

20. The aortic valve opens and closes at points:

- A. 4. and 1. respectively
- B. 1. and 2. respectively
- C. 2. and 3 respectively
- D. 3. and 4. respectively
- E. 4. and 2. respectively

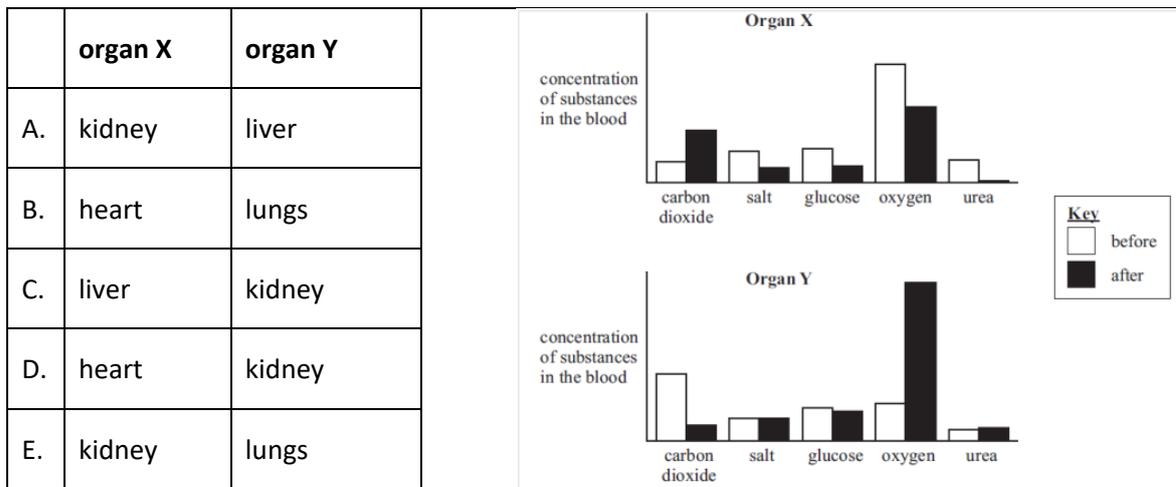
21. Stroke volume is the volume ejected from the ventricle on each beat. Cardiac output can be calculated by multiplying stroke volume by heart rate. If for the Fig. 2 the heart rate is 70 beats per minute, the cardiac output of this ventricle is closest to:

- A. 3.45 L/min
- B. 4.05 L/min
- C. 5.25 L/min
- D. 8.00 L/min
- E. 9.85 L/min

22. Ejection fraction is the fraction of the end-diastolic volume ejected in each stroke volume. A hospitalized patient has an ejection fraction of 0.4, a heart rate of 95 beats per minute, and a cardiac output of 3.5 L/min. What is the patient's end-diastolic volume?

- A. 14 mL
- B. 37 mL
- C. 55 mL
- D. 92 mL
- E. 140 mL

23. Concentration of five substances has been measured in the blood entering and then leaving two organs, X and Y. Results of these measurements are shown in the graphs below. Indicate which organs have been studied:



24. Prolactin is the major hormone responsible for lactogenesis. Prolactin secretion from the anterior pituitary is tonically inhibited by dopamine secreted by the hypothalamus. Prolactin excess resulting from prolactin-secreting tumors is treated with bromocriptine acting as a dopamine agonist. The basis for the therapeutic action of bromocriptine is that it:

- A. enhances the action of dopamine on the anterior pituitary.
- B. antagonizes the action of prolactin on the breast.
- C. inhibits prolactin release from the anterior pituitary.
- D. inhibits prolactin release from the hypothalamus.
- E. enhances the action of prolactin on the breast.

25. Based on Fig. 3, decide what causes increased secretion of oxytocin from the posterior pituitary gland.

- A. Milk ejection
- B. Fever
- C. Increased prolactin level
- D. Dilation of the cervix
- E. Uterine contraction

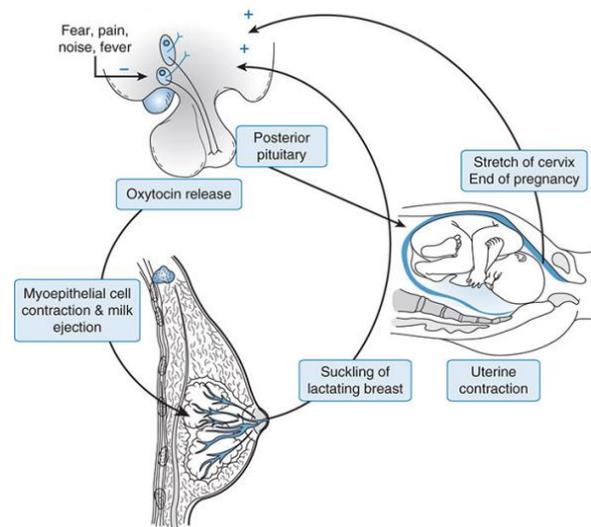


Fig. 3

26. Fig. 4 shows pathways of biosynthesis of glucocorticoids, androgens, and mineralocorticoids in the adrenal cortex. Which step, if inhibited, blocks the production of all androgenic compounds but does not block the production of glucocorticoids?

- A. Aldosterone synthase
- B. Lack of ACTH
- C. 17,20-Lyase
- D. Cholesterol desmolase
- E. Aromatase

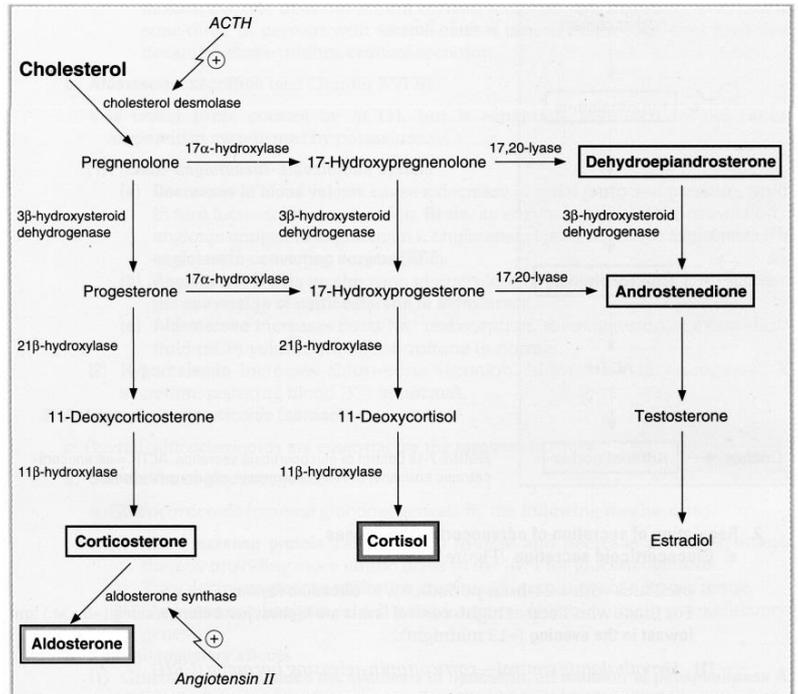


Fig. 4

27. A patient comes to the dentist to remove plaque and calculus deposits from the teeth. The dentist notices a big lump on the oral mucosa during inspection. The lump is not painful but causes discomfort to the patient. The patient also reports smoking 10 cigarettes per day for the past 15 years. Furthermore, he lost 10 kg of weight over the recent months, and says he feels weak. What should the dentist do?

- A. Ignore the lump since it's not infectious, and take care of the plaque.
- B. Refer the patient to a specialist doctor with suspicion of a neoplasm/tumour.
- C. Remove the lump and discard it.
- D. Inject the lump with steroids to diminish its size.
- E. Inject the lump with antibiotics to diminish its size.

28. The menstrual cycle starts with menses, but consists of the follicular and luteal phases separated by ovulation. The luteal phase is always 14 days long. Thus, in a 35-day menstrual cycle, ovulation occurs on day:

- A. 12
- B. 14
- C. 17
- D. 21
- E. 28

29. A dentist needs to remember that caries, one of the most common conditions that they will be treating in their office, are related to:

- A. the action of microorganisms.
- B. a diet rich in carbohydrates.
- C. the use of alcohol-containing mouthwash.
- D. answers A. and B. are correct.
- E. answers A., B. and C. are correct.

30. Explain what the medical term for *osteoporosis* stands for:

- A. the pores in your skin
- B. bone loss
- C. loss of hearing
- D. weight loss
- E. dislocation of the joint

31. If one's diabetes isn't under control, it can harm:
- A. the liver.
  - B. the eyes and the kidneys.
  - C. the heart.
  - D. B and C
  - E. A and C
32. What does insulin do?
- A. Lets blood sugar leave the liver.
  - B. Helps cells take in blood sugar.
  - C. Helps cells keep out blood sugar.
  - D. Lets your body release adrenaline.
  - E. Raises the level of glucose in blood.
33. Type 1 diabetes is a condition where:
- A. the body is unable to produce glucose and lacks energy as a result.
  - B. the body creates too many ketones.
  - C. the body cannot produce any insulin at all.
  - D. the body cannot properly use its insulin.
  - E. the body cannot produce the glucose.
34. Which medical term describes the red blood cells:
- A. Leukocyte
  - B. Lymphocyte
  - C. Erythrocyte
  - D. Granulocyte
  - E. Monocyte
35. Carotenoids are especially present in:
- A. meat products.
  - B. dairy products.
  - C. fruits and vegetables.
  - D. sausage.
  - E. energy drinks.

**The following text refers to questions 36-40.**

Tetanus is a vaccine-preventable disease that still commonly occurs in many low-income and middle-income countries, although it is rare in high-income countries. The disease is caused by the toxin of the bacterium *Clostridium tetani* and is characterised by muscle spasms and autonomic nervous system dysfunction. Global vaccination initiatives have had considerable success but they continue to face many challenges. Treatment for tetanus aims to control spasms and reduce cardiovascular instability, and consists of wound debridement, antitoxin, antibiotics, and supportive care. Recent research has focused on intravenous magnesium sulphate and intrathecal antitoxin administration as methods of spasm control that can eliminate the need for ventilatory support. Nevertheless, without access to mechanical ventilation, mortality from tetanus remains high. Even with such care, patients require several weeks of hospitalisation and are vulnerable to secondary problems, such as hospital-acquired infections.

(Source: Lam Minh Yen, C Louise Thwaites; *Lancet* 2019; 393: 1657–68)

36. Which of the statements is true?
- A. There is still no efficient vaccine against tetanus.
  - B. Proper treatment of tetanus is a mainstay of current approach to the disease control.
  - C. Clostridium tetani produces a neurotoxin.
  - D. Intravenous antitoxin administration is a new method of spasm control.
  - E. All the above answers are wrong.
37. Autonomic system dysfunction in tetanus is characterized mainly by:
- A. muscle spasms.
  - B. higher incidence of secondary hospital-acquired infections.
  - C. impairment in wound healing.
  - D. cardiovascular instability.
  - E. Answers A and D are correct.
38. Currently, the most important factor influencing the mortality from tetanus is:
- A. immediate use of antitoxin.
  - B. use of broad-spectrum antibiotics.
  - C. access to mechanical ventilation.
  - D. early wound debridement.
  - E. supportive care during long hospitalization.
39. What is the most plausible mechanism of beneficial action of magnesium sulphate?
- A. Direct toxic effect on Clostridium tetani.
  - B. Chemical inactivation of bacterial toxin.
  - C. Stabilization of heart rate in patients.
  - D. Relaxation of muscles.
  - E. Stimulation of ventilation center in central nervous system.
40. Recent research on the treatment of tetanus focuses on:
- A. avoiding the need of mechanical ventilation.
  - B. discovery of better vaccine.
  - C. optimization of supportive care to prevent secondary problems.
  - D. use of new antibiotics to kill bacteria.
  - E. use of cardiovascular drugs to stabilize the heart rate.

**Questions 41 – 42 Atoms, isotopes, molecules**

Isotopes  ${}^A_Z\text{E}$  are variants of a particular chemical element (E) which differ in the number of neutrons and, consequently, in the mass number (A). All isotopes of a given element have the same number of protons (Z) in each atom.

41. Mohr's salt is a type of the so-called double salt. It assumes the following chemical formula  $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ . Use the information of the most abundant isotopes below to calculate the molar mass of the hydrated salt.
- Most abundant isotopes:  ${}^1_1\text{H}$ ,  ${}^{14}_7\text{N}$ ,  ${}^{16}_8\text{O}$ ,  ${}^{32}_{16}\text{S}$ ,  ${}^{56}_{26}\text{Fe}$ .
- A. 144
  - B. 204
  - C. 284
  - D. 360
  - E. 392

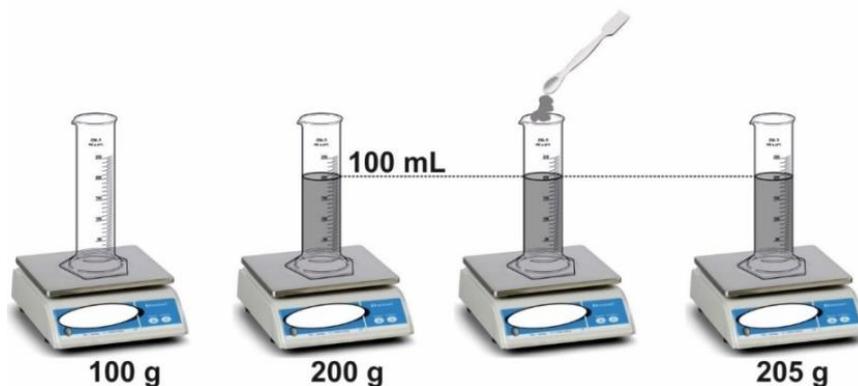


47. Isoelectronic species are molecules or ions that have the same or equal number of electrons. Which of the following groups of species are isoelectronic?
- $\text{N}_2$ ,  $\text{CO}$ ,  $\text{NO}^+$
  - $\text{O}_2$ ,  $\text{NO}$
  - $\text{HF}$ ,  $\text{CN}$
  - $\text{N}_2^-$ ,  $\text{O}_2^-$
  - $\text{N}_2$ ,  $\text{CN}$

**The following text refers to questions 48 – 49**

Mass percent is used as a way of expressing concentration, or a way of describing a component in a mixture. For a solution, the mass percent is expressed as the grams of *solute* divided by the grams of *solution*, then multiplied by 100 to get a percentage.

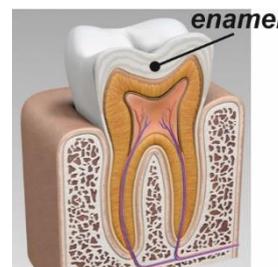
48. A student is preparing a solution of NaCl in water. They use a balance and a measuring cylinder. The illustration shows consecutive stages of their work, with some of the readings on the balance and some on the measuring cylinder. Which calculation should be used to determine the mass percent concentration of the resulting solution?



- $\frac{205}{100+200} * 100\%$ .
  - $\frac{205}{205-100} * 100\%$ .
  - $\frac{205}{205-100-100} * 100\%$ .
  - $\frac{200-100}{205-100-100} * 100\%$ .
  - $\frac{205-100}{205-100} * 100\%$ .
  - It cannot be concluded because information about density of the solution has not been provided.
49. 200 g of 20% (weight percent) aqueous solution of NaCl contains:
- 40 g of NaCl and 160 g of water.
  - 20 g of NaCl and 180 g of water.
  - 40 g of NaCl and 180 g of water.
  - 60 g of NaCl and 140 g of water.
  - 140 g of NaCl and 60 g of water.

50. Tooth enamel makes up the normally visible part of the tooth, covering the crown. Enamel is the hardest substance in the human body and contains the highest percentage of minerals. The primary mineral is hydroxyapatite, which is a crystalline calcium phosphate for which the content of phosphorus is 18.5 weight %. What is the formula of hydroxyapatite?

- A.  $\text{CaHPO}_4$
- B.  $\text{Ca}(\text{H}_2\text{PO}_4)_2$
- C.  $\text{Ca}_3(\text{PO}_4)_2$
- D.  $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$
- E.  $\text{Ca}_3(\text{HPO}_4)_2(\text{OH})_2$



51. Disproportionation is the simultaneous oxidation and reduction of the same species in a reaction. Which of the following is/are disproportionation reaction(s)?

1.  $\text{Fe} + \text{CuCl}_2 \rightarrow \text{FeCl}_2 + \text{Cu}$
2.  $\text{Cu}_2\text{O} \rightarrow \text{Cu} + \text{CuO}$
3.  $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HClO}$
4.  $\text{BaCl}_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{NaCl}$
5.  $2\text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2$

- A. 2. only.
- B. 2. and 3.
- C. 3. and 4.
- D. 1., 4. and 5.
- E. 2., 3. and 5.

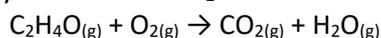
52. How many grams of carbon dioxide ( $\text{CO}_2$ ) can be obtained by burning 6.0 g of carbon (C) in 8.0 g of oxygen ( $\text{O}_2$ ):  $\text{C} + \text{O}_2 = \text{CO}_2$ ? (atomic masses: C = 12; O = 16)

- A. 11 g
- B. 14 g
- C. 22 g
- D. 33 g
- E. 44 g

53. What is the volume of hydrogen gas formed (measured at room temperature and pressure) when 2.3 g of pure sodium reacts completely with an excess of water? (atomic masses: H = 1.0; Na = 23) Assume that the molar volume of gas at room temperature and pressure is  $24 \text{ dm}^3$ .

- A.  $1.0 \text{ dm}^3$
- B.  $1.2 \text{ dm}^3$
- C.  $2.0 \text{ dm}^3$
- D.  $2.4 \text{ dm}^3$
- E.  $4.8 \text{ dm}^3$

54. What is the stoichiometry coefficient of  $\text{O}_2$  in the following equation?



- A. 2
- B. 3
- C. 4
- D. 5
- E. 6

55. pH of a certain aqueous solution was examined. The result was  $\text{pH} = 3.2$ . Which of the following substances dissolved in water could be the solute?

- A. NaCl
- B.  $\text{H}_3\text{PO}_4$
- C.  $\text{C}_2\text{H}_5\text{OH}$
- D.  $\text{NH}_3$
- E. NaOH

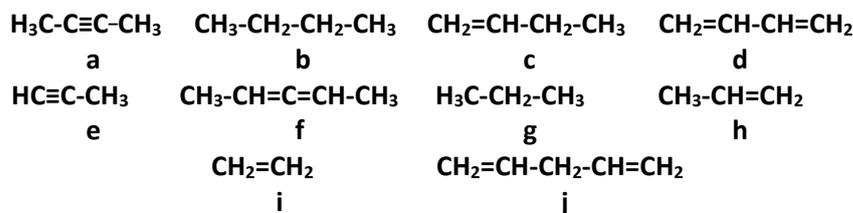
56. During electrolytic dissociation of sodium sulfate in water, the following ions are produced in the given molar ratio:
- $\text{Na}^+$  and  $\text{SO}_4^{2-}$
  - $2\text{Na}^+$  and  $\text{SO}_4^{2-}$
  - $\text{Na}^+$  and  $2\text{SO}_4^{2-}$
  - $2\text{Na}^+$  and  $2\text{SO}_4^{2-}$
  - Sodium sulfate is not an ionic substance and does not dissociate in water.

57. Dry ice is the solid form of carbon dioxide. At atmospheric pressure, carbon dioxide cannot retain liquid form. Thus, upon heating at ambient conditions, dry ice undergoes:
- melting.
  - resublimation.
  - boiling.
  - sublimation.
  - deposition.

58. A conjugate acid, within the Brønsted–Lowry acid–base theory, is a chemical compound formed by the reception of a proton ( $\text{H}^+$ ) by a base. In other words, it is a base with a hydrogen ion added to it. Which of the following compounds or ions form the conjugate acid–base system:



- $\text{CH}_3\text{-NH}_3^+$  and  $\text{CH}_3\text{COOH}$
  - $\text{CH}_3\text{-NH}_3^+$  and  $\text{CH}_3\text{-NH}_2$
  - $\text{CH}_3\text{-NH}_2$  and  $\text{CH}_3\text{COO}^-$
  - $\text{CH}_3\text{-NH}_2$  and  $\text{CH}_3\text{COOH}$
  - none of the above
59. Chemists order the organic compounds in series called the homologous series. The members of such series differ by  $-\text{CH}_2-$  (methylene) group and usually have similar chemical properties, but their physical properties change proportionally to the number of atoms in the molecule. Which of the following hydrocarbons form a homologous series?



- c, e, j
- c, h, i
- a, i, j
- g, d, f
- b, c, d

60. Fig. 6 presents a structural formula of prostaglandin PGE<sub>2</sub>, a member of prostaglandin family – hormones that elicit an unusually diverse array of physiological responses.

This is a line-angle (skeleton) formula. Assuming that in this mode of presentation, the carbon atoms appear at the end of each segment and all carbon atoms are connected with the number of hidden hydrogen atoms corresponding to their valence\*, choose the correct molecular formula of PGE<sub>2</sub>:

- A. C<sub>20</sub>H<sub>30</sub>O<sub>5</sub>
- B. C<sub>20</sub>H<sub>32</sub>O<sub>4</sub>
- C. C<sub>20</sub>H<sub>32</sub>O<sub>5</sub>
- D. C<sub>19</sub>H<sub>30</sub>O<sub>5</sub>
- E. C<sub>19</sub>H<sub>32</sub>O<sub>5</sub>

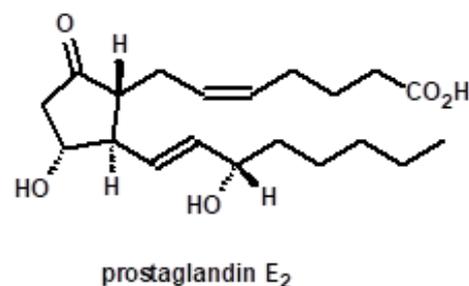
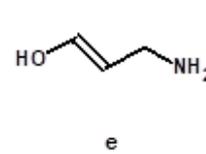
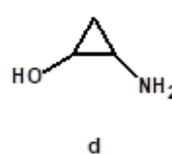
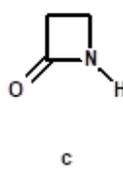
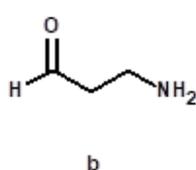
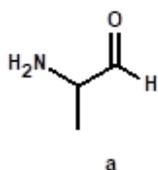


Fig. 6

\*Valence is the property of an element that determines the number of other atoms with which an atom of the element can combine; hydrogen and halogens are usually monovalent; oxygen and sulphur divalent; nitrogen and phosphorus trivalent; and carbon tetravalent.

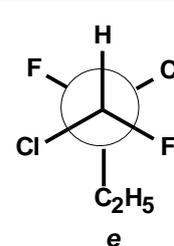
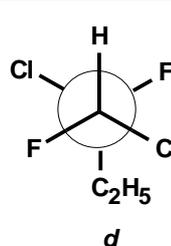
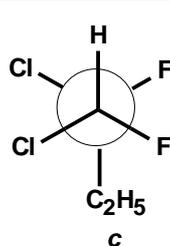
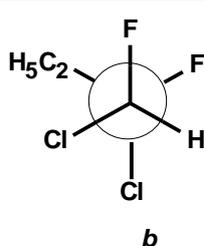
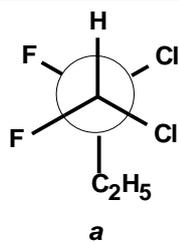
61. Structural isomers of organic compounds have the same molecular formula (composition), but a different way of bonding atoms with each other. Which of the following compounds IS NOT an isomer of all the others?

- A. a
- B. b
- C. c
- D. d
- E. e



The following text refers to questions 62- 63.

Below, various Newman projections along C<sup>1</sup>-C<sup>2</sup> bond of 1,2-dichloro-1,2-difluorobutane are shown. (Remember that in Newman projection 3 substituents at C<sup>1</sup> are shown in front of the circle, and 3 substituents at C<sup>2</sup> are shown behind the circle. The free rotation along C-C bond is possible and is well depicted by this projection).



62. Which of them depict the same stereoisomer?

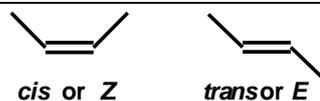
- A. a and b
- B. a and c
- C. a and d
- D. b and c
- E. a and e

63. Which of them depict enantiomers (for definition see questions 67)?

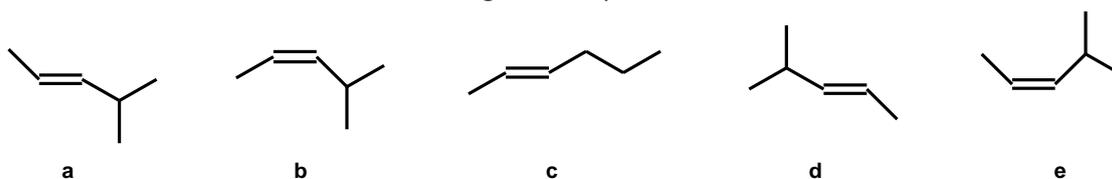
- A. a and b
- B. a and c
- C. a and d
- D. b and e
- E. b and d

**The following text refers to questions 64-66**

Stereoisomers of organic compounds have the same structure (the way the atoms bond with each other), but a different spatial arrangement of atoms. In the molecules with double bond between carbon atoms, where no free rotation is possible, *cis/trans* or *Z/E* stereoisomers occur. Already in but-2-en (below), two methyl groups can be found on the same side of the double bond → *cis* or *Z* isomer, or on the opposite sides of the double bond → *trans* or *E* isomer:



Below, some structural formulas of some organic compounds are shown:



64. Which of them are structural isomers?

- A. a and b
- B. a and c
- C. b and d
- D. d and e
- E. b and e

65. Which of them depict identical stereoisomers?

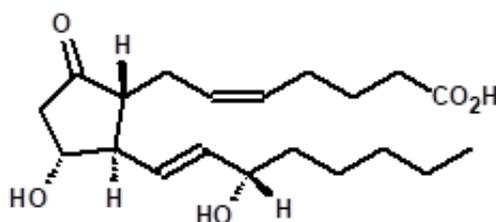
- A. a and d
- B. d and e
- C. c and d
- D. b and c
- E. a and e

66. Which of them form a pair of different stereoisomers?

- A. a and b
- B. b and d
- C. b and c
- D. a and d
- E. A. and B. are correct

67. In the case of optically active compounds (e.g. Prostaglandin  $E_2$ ) that are chiral i.e. their forms are as an object and its mirror image (enantiomers), which is due to the presence of a stereogenic centre (or more of them). A stereogenic centre (chiral atom) is a carbon atom with four different substituents (also when it constitutes a part of a ring). How many stereogenic centres are present in the following prostaglandin  $E_2$  molecule?

- A. 1
- B. 2
- C. 3
- D. 4
- E. 5

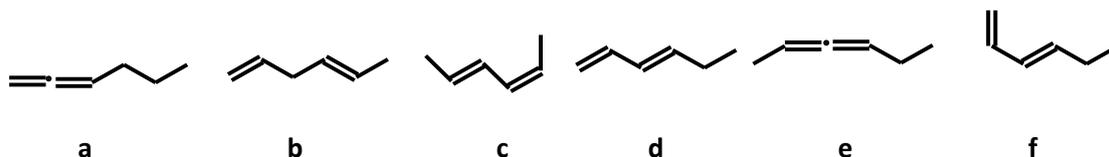


prostaglandin  $E_2$

**The following text refers to questions 68-69**

For unsaturated hydrocarbons (or other organic compounds), the double bonds can be cumulated (placed at the same carbon atom), conjugated (separated by one single bond) or isolated (separated by more than one single bond). The most important systems with conjugated multiple bonds are more stable than similar systems with isolated or cumulated multiple bonds due to the delocalisation of electrons over the whole system.

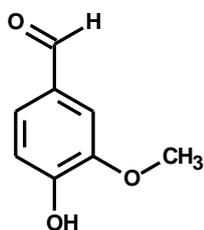
68. Which of these compounds contain exclusively those with conjugated systems of multiple bonds?



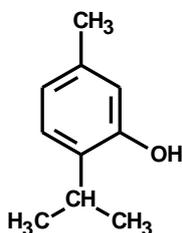
- A. b, d, f  
 B. a, d, e  
 C. c, d, f  
 D. b, c, e  
 E. a, b, c

69. Which of the following natural compounds has the highest percentage content of oxygen (atomic masses: C = 12 g/mole, H = 1 g/mole, O = 16 g/mole)?

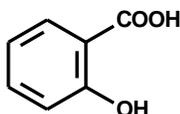
- A. B. C. D. E.



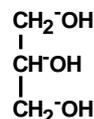
vanillin



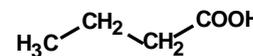
thymol



salicylic acid



glycerol



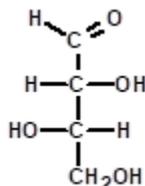
butyric acid

**The following text refers to question 70**

Molecules that contain stereogenic centres (for definition see question 67) exhibit stereoisomers. With  $n$  stereogenic centres there is a possibility of  $2^n$  stereoisomers formation.

70. How many stereoisomers are possible for this carbohydrate:

- A. 1  
 B. 2  
 C. 3  
 D. 4  
 E. 5



**The following text refers to questions 71-76.**

Abstract: Drinking water contamination with heavy metals, particularly lead, is a persistent problem worldwide with grave public health consequences. Existing purification methods often cannot address this problem quickly and economically. Here we report a cheap, water stable metal-organic framework/polymer composite, Fe-BTC\*/PDA, that exhibits rapid, selective removal of large quantities of heavy metals, such as  $Pb^{2+}$  and  $Hg^{2+}$ , from real world water samples. In this work, Fe-BTC is treated with dopamine, which undergoes a spontaneous polymerization to polydopamine (PDA) within its pores via  $Fe^{3+}$  open metal sites. The PDA, pinned on the internal MOF surface, gains extrinsic porosity, resulting in a composite that binds up to 1634 mg of  $Hg^{2+}$  and 394 mg of  $Pb^{2+}$  per gram of composite and removes more than 99.8% of these ions from a 1ppm solution, yielding drinkable levels in seconds. Further, the composite properties are well-maintained in river and seawater samples spiked with only trace amounts of lead, illustrating unprecedented selectivity. Remarkably, no significant uptake of competing metal ions is observed even when interferents, such as  $Na^+$ , are present at concentrations up to 14 000 times that of  $Pb^{2+}$ . The material is further shown to be resistant to fouling when tested in high concentrations of

common organic interferents, like humic acid, and is fully regenerable over many cycles.

Source: *Rapid, Selective Heavy Metal Removal from Water by a Metal-Organic Framework/Polydopamine Composite*. Daniel T. Sun, Li Peng, Washington S. Reeder, Seyed Mohamad Moosavi, Davide Tiana, David K. Britt, Emad Oveisi, and Wendy L. Qjueen; *ASC Cent. Sci.* 2018, 4, 349

\*Fe-BTC is a trade product of BASF Basolite® F 300  
(iron 1,3,5-benzenetricarboxylate)

71. Which of the following statements is not true according to the text?
- Removal of heavy metals from drinking water is a vital problem nowadays.
  - Existing water purification methods are rather cheap.
  - The iron-organic framework/polymer composite synthesised by the authors of this paper is water stable.
  - This composite offers selective removal of heavy metals from water.
  - This composite can be used also for river or sea water.
72. Which of the following statements cannot be directly concluded from the text?
- Polydopamine in a composite is formed by spontaneous polymerisation of dopamine.
  - This polymerisation is catalysed by  $Fe^{3+}$  open metal sites.
  - Polydopamine synthesised in this way shows remarkable porosity.
  - Heavy metals such as Pb or Hg play no role in human homeostasis.
  - Common metal ions like e.g.  $Na^+$  present in water have no influence on heavy metals removal.
73. Looking at a puzzle in the picture, indicate which metal(s) can be effectively removed from water by the action of the composite.
- potassium and lead
  - lead and calcium
  - sodium and lead
  - sodium only
  - lead only

74. Which of the advantages of this new composite is not mentioned in the text?
- selectivity
  - resistance to fouling
  - ability to work repeatedly
  - easy synthetic procedure
  - low cost of preparation
75. How many milligrams of  $Pb^{2+}$  can be maximally absorbed by 5 grams of the composite?
- 394 mg
  - 788 mg
  - 1182 mg
  - 1970 mg
  - 1634 mg
76. How many grams of  $Hg^{2+}$  can be maximally absorbed by 3 grams of the composite?
- 4.9 g
  - 1.6 g
  - 3.3 g
  - 6.5 g
  - 0.4 g

**The following text refers to questions 77-82**

**Public health problems**

Diseases of the mouth are a highly prevalent noncommunicable disease in European countries. Between 20% and 90% of 6-year-old children have dental caries, and at age 12, an average of 0.5–3.5 permanent teeth are affected by this disease. In European countries, nearly 100% of adults have experience of this disease and between the ages of 35–44 years, an average of 10–20 teeth have dental decay. Dental caries is a major cause of complete loss of natural teeth and this condition affects 30% of older Europeans in the age group 65–74 years. The prevalence rate of older people having lost all their natural teeth varies by country from 5% to 51%.

**Inequity in oral health**

Across Europe, the disease conditions are particularly frequent or severe among underprivileged and disadvantaged population groups, and socioeconomic factors also play a crucial role in the scope of services covered by primary oral health care. In many countries, both poor children and adults are underserved by dental care since access to dental care is not equitable.

Economic burden Diseases of the mouth are a costly burden to health care services. The treatment of dental diseases is expensive, accounting for between 5% and 10% of total public health care expenditures in European countries. In the European Union, the annual cost of dental care is estimated at 79 billion euros.

Source: [http://www.euro.who.int/\\_data/assets/pdf\\_file/0009/365850/oral-health-2018-eng.pdf?ua=1](http://www.euro.who.int/_data/assets/pdf_file/0009/365850/oral-health-2018-eng.pdf?ua=1)

**Choose if the following statements are true (T) or false (F)**

- |   |   |   |
|---|---|---|
| 77. The prevalence of older Europeans with tooth decay varies from 5% to 51%.   | T | F |
| 78. Diseases of the mouth are of minor concern in European countries.   | T | F |
| 79. The low socio-economic status is a risk for bad oral health in European countries.  | T | F |
| 80. From the point of view of economic burden in Europe, the treatment of dental diseases generates a small part of public health care costs. | T | F |
| 81. Dental caries affect almost every person in the European population.  | T | F |
| 82. Dental caries affects 30% of Europeans in the age group 65-74 years.  | T | F |

The following statement refers to questions 83-86.

The book 'XXXX' is the only book focusing on the problem of poverty in China between 1950 and 1980.

Choose if the following statements are true (T) or false (F)

- |   |   |   |
|---|---|---|
| 83. Poverty was not an issue before 1950.                           | T | F |
| 84. No other book deals with poverty in China during 1950 to 1980.  | T | F |
| 85. Only one book was published in China during the years 1950-1980 | T | F |
| 86. There were no poor people in China after the year 1980.         | T | F |

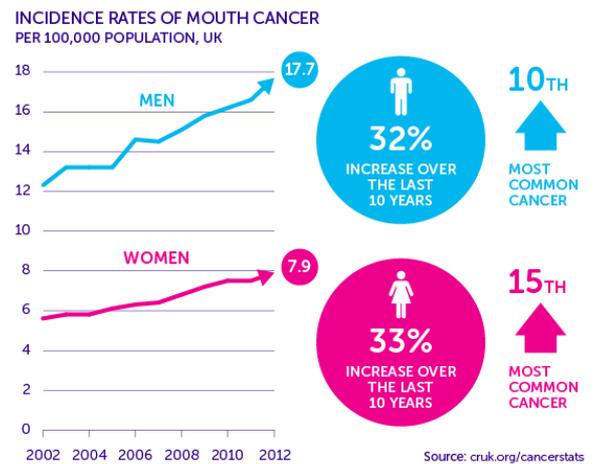
87. Choose a number to complete the sequence: **104, 109, 115, 122, 130.....**

- A. 119
- B. 125
- C. 132
- D. 139
- E. 145

88. Fig. 7 presents the oral cancer incidence rates (new cases of oral cancer per 100 000 population) in the United Kingdom. Which of the following conclusions can be drawn based on the data presented in Fig. 7?

- A. The number of mouth cancer cases is higher among females than among males.
- B. The incidence of oral cancer in the UK over ten years (2002-2012) has been decreasing systematically.
- C. The incidence of oral cancer in the UK is over 2-times higher among females than among males.
- D. Over the decade, the level of oral cancer was stable among women, but increased among men.
- E. The number of new cases of oral cancer has increased slower among females than among males (per 100 000 males and females, respectively).

### MOUTH CANCER RATES ON THE RISE



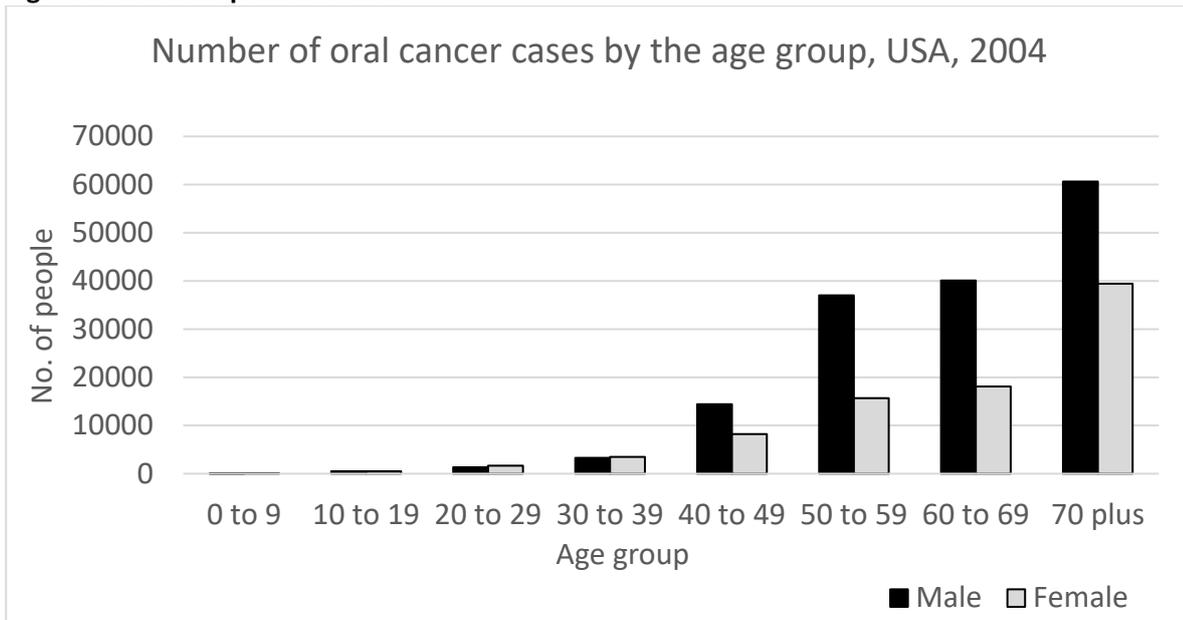
WE WILL BEAT CANCER SOONER  
cruk.org



**Fig. 7**

Sources: <https://zniup3zx6m0ydaqfpv9y6sgtf-wpengine.netdna-ssl.com/wp-content/uploads/2015/11/151113-Mouth-cancer-rates.png>  
[https://www.who.int/gho/child\\_health/child\\_health\\_001.png?ua=1](https://www.who.int/gho/child_health/child_health_001.png?ua=1)

Figure 8 refers to questions 89-92



**Fig. 8** Data on Oral Cancer (Total Number of Cases) by Gender and Age in the USA in 2004.

**Source:** Surveillance, Epidemiology, and End Results (SEER) Program, National Cancer Institute U.S. 2006 cancer prevalence counts are based on 2006 cancer prevalence proportions from the SEER 9 registries (San Francisco, Connecticut, Detroit, Hawaii, Iowa, New Mexico, Seattle, Utah, and Atlanta) <https://www.nidcr.nih.gov/research/data-statistics/oral-cancer/prevalence>

**Based on the data presented in Fig. 8, chose if the following statements are true (T) or false (F)**

- 89. Oral cancer is diagnosed only in the adult population. T    F
- 90. In males, oral cancer is more prevalent than in females across age groups. T    F
- 91. The number of new cases of oral cancer increases with age. T    F
- 92. Total number of oral cancer cases in the USA in 2004 is higher among males than among females. T    F

**The following text refers to questions 93-94**

In a small company, parking spaces are reserved for the top executives: CEO, president, vice president, secretary, and treasurer with the spaces lined up in that order. The parking lot guard can tell at a glance if the cars are parked correctly by looking at the colors of the cars. The cars are yellow, green, purple, red, and blue, and the executives names are Anna, Beatrice, Cheryl, David, and Ella.

- \* The car in the first space is red.
- \* Blue car is parked between the red car and the green car.
- \*The car in the last space is purple.
- \*Anna's car is parked next to David's.
- \*Ella drives a green car.
- \*Beatrice's car is parked between Cheryl's and Ella's.
- \*David's car is parked in the last space.

93. Who is the secretary?

- A. Anna
- B. Beatrice
- C. Cheryl
- D. David
- E. Ella

94. Whose car is blue?

- A. Anna's
- B. Beatrice's
- C. Cheryl's
- D. David's
- E. Ella's

95. Jack collects stamps. He has received 20 stamps from his friend Gary. Jack's sister – Tamara gave him 1/2 of the stamps he received from Gary, and Mary gave him 1/2 the stamps he received from Gary and Tamara combined. How many stamps did Jack receive from Mary?

- A. 45
- B. 20
- C. 15
- D. 10
- E. 5

96. Mark starts from his house and travels 4 km eastwards, after that he turns left and travels for 4 km. Finally, he turns left and travels for 4 km. At what distance from and in which direction in relation to his original position does he find himself?

- A. North, 4 km
- B. North-East, 4 km
- C. South, 12 km
- D. West, 12 km
- E. None of the above

97. If 15 men can reap the crops of a field in 28 days, in how many days will 5 men reap it?

- A. 9.333 days
- B. 45 days
- C. 50 days
- D. 60 days
- E. 84 days

98. Laura: *Pure research provides us with new technologies that contribute to saving lives. Even more worthwhile than this, however, is its role in expanding our knowledge and providing new, unexplored ideas.*

Kim: *Your priorities are mistaken. Saving lives is what counts most of all. Without pure research, medicine would not be as advanced as it is.*

Laura and Kim disagree on whether pure research:

- A. derives its significance in part from its providing new technologies.
- B. expands the boundaries of our knowledge of medicine.
- C. should have the saving of human lives as an important goal.
- D. has most valuable achievements in medical applications.
- E. has any value apart from its role in providing new technologies to save lives.

99. The ages of Alice and Tom differ by 16 years. 6 years ago, Alice was 3 times as old as Tom. What is the present age of Alice?

- A. 10 Years
- B. 20 Years
- C. 30 Years
- D. 40 Years
- E. 50 Years

100. A pipe can fill a tank in 6 hours, while another pipe can empty the tank in 12 hours. If both the pipes are opened at the same time, the tank can be filled in:

- A. 6 hours
- B. 10 hours
- C. 12 hours
- D. 14 hours
- E. 16 hours

**End of the test**

**THE KEY**

1. D, 2. C, 3. E, 4. B, 5. C, 6. D, 7. C, 8. B, 9. E, 10. E, 11. C, 12. C, 13. D, 14. C, 15. C, 16. B, 17. B, 18. B, 19. B, 20. C, 21. C, 22. D, 23. E, 24. C, 25. D, 26. C, 27. B, 28. D, 29. D, 30. B, 31. D, 32. B, 33. C, 34. C, 35. C, 36. C, 37. D, 38. C, 39. D, 40. A, 41. E, 42. B, 43. C, 44. E, 45. E, 46. C, 47. A, 48. D, 49. A, 50. D, 51. E, 52. A, 53. B, 54. D, 55. B, 56. B, 57. D, 58. B, 59. B, 60. C, 61. C, 62. A, 63. B, 64. B, 65. A, 66. E, 67. D, 68. C, 69. D, 70. D, 71. B, 72. D, 73. E, 74. D, 75. D, 76. A, 77. F, 78. F, 79. T, 80. F, 81. T, 82. F, 83. F, 84. T, 85. F, 86. F, 87. D, 88. E, 89. F, 90. F, 91. F, 92. T, 93. A, 94. B, 95. C, 96. A, 97. E, 98. D, 99. C, 100. C.