

Welcome to the first round of the Chemistry Olympiad 2025/26!

The exam consists of 37 single choice questions.

Each task has only one correct solution. No points are deducted for an incorrect answer.

The exam lasts 40 minutes. At the end of the time, your exam will be submitted automatically.

The exam must be completed independently. All AI tools and the internet are not permitted as aids.

The only permitted aids are your own notes, documents, books and a calculator.

Good luck!

Duration: 40 minutes

1 First Round 2025/26

First Round Chemistry Olympiad 2025/26

Question 1

How much potassium nitrate needs to be weighed out for 0.5 L of a $1.75 \text{ mol} \cdot \text{L}^{-1}$ solution of KNO_3 ?

- A. 50.55 g
- B. 88.46 g
- C. 75.83 g
- D. 101.10 g

Question 2

Which atom has the largest atomic radius?

- A. Na
- B. Mg
- C. Si
- D. P

Question 3

Which ion has the smallest ionic radius?

- A. F^-
- B. Cl^-
- C. Br^-
- D. At^-

Question 4

Which bond is energetically most stable?

- A. H-F
- B. H-Cl
- C. H-Br
- D. H-I

Question 5

Which electron configuration given below corresponds to the Element Pr?

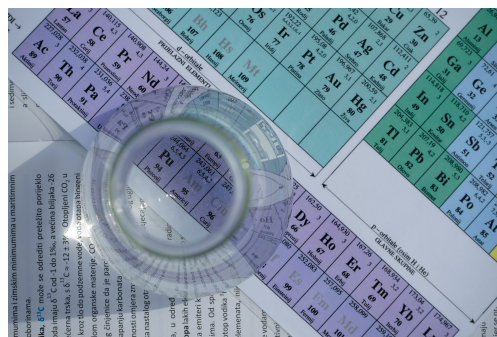
- A. $[\text{Xe}] 6s^2 4f^3$
- B. $[\text{Xe}] 6s^2 4f^5$

C. $[\text{Xe}] 6s^2 4f^7$

D. $[\text{Xe}] 6s^2 4f^{14} 5d^1$

Question 6

What is the oxidation state of Pr in Pr_2O_3 ?



- A. +I
- B. +II
- C. +III
- D. +IV

Question 7

Praseodymium has an isotope ^{141}Pr .

Which of the following correctly gives the number of protons, neutrons, and electrons in a neutral atom of this isotope?

- A. 59 protons, 82 neutrons, 59 electrons
- B. 59 protons, 141 neutrons, 59 electrons
- C. 59 protons, 82 neutrons, 82 electrons
- D. 141 protons, 59 neutrons, 141 electrons

Question 8

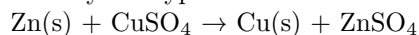
Praseodymium is added to magnesium-based alloys to enhance strength under high temperatures.

What is an alloy?

- A. A compound made by chemically bonding two nonmetals
- B. A mixture of a metal with one or more elements to improve its properties
- C. A pure metal that is heat treated to increase its hardness
- D. A solution made by dissolving metals in acids

Question 9

Identify the type of reaction shown below:





- A. Electrophilic reaction
- B. Redox reaction
- C. Nucleophilic substitution
- D. None of them

Question 10

How many grams of methyl ethanoate contains y oxygen atoms?

Let Avogadro's constant be N_A .

- A. $88y/N_A$ g
- B. $74y/N_A$ g
- C. $44y/N_A$ g
- D. $37y/N_A$ g

Question 11

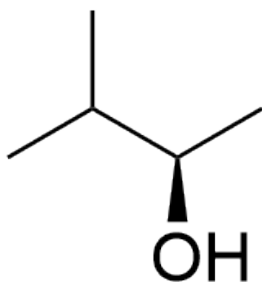
The density of pure nitric acid at room temperature and pressure is $1.513 \text{ g}\cdot\text{cm}^{-3}$. (Density of water = $1 \text{ g}\cdot\text{cm}^{-3}$)

The density of $8 \text{ mol}\cdot\text{L}^{-1}$ nitric acid is closest to:

- A. $1.17 \text{ g}\cdot\text{cm}^{-3}$
- B. $1.28 \text{ g}\cdot\text{cm}^{-3}$
- C. $1.39 \text{ g}\cdot\text{cm}^{-3}$
- D. $1.45 \text{ g}\cdot\text{cm}^{-3}$

Question 12

The structure of compound **A** is shown below:
The systematic name of **A** is



- A. (*S*)-2-methylbutan-3-ol
- B. (*R*)-3-methylbutan-2-ol

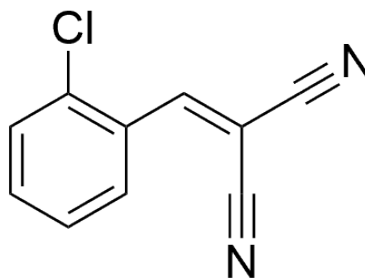
- C. (*S*)-1,1-dimethylpropan-2-ol
- D. (*R*)-3,3-dimethylpropan-2-ol

Question 13

Consider the following compound **B**

Which of the following statements are true?

- (1) The molecular formula of **B** is $\text{C}_{10}\text{H}_5\text{N}_2\text{Cl}$.
- (2) **B** does not exhibit *E/Z* isomerism.
- (3) Some carbon atoms in **B** do not follow the octet rule.



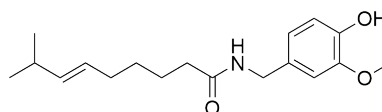
- A. (1) and (2) only
- B. (1) and (3) only
- C. (2) and (3) only
- D. (1), (2) and (3)

Question 14

Capsaicin is responsible for the spiciness in some food. The structure is shown below:

Which of the following statements concerning capsaicin is/are true?

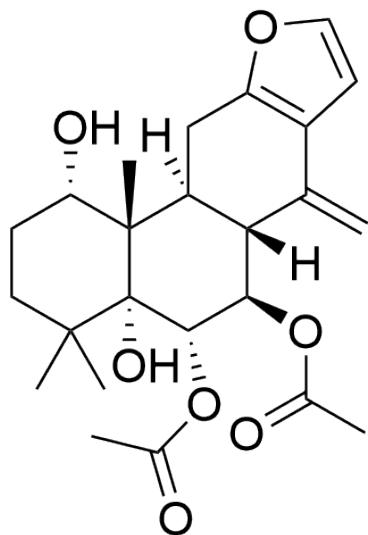
- (1) Capsaicin contains an amine group.
- (2) Capsaicin is not optically active.
- (3) Capsaicin exhibits *cis/trans* isomerism.



- A. (1) and (2) only
- B. (1) and (3) only
- C. (2) and (3) only
- D. (1), (2) and (3)

Question 15

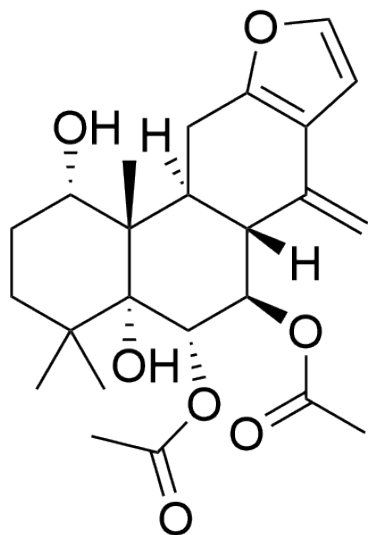
Which of the following functional groups does not exist in the structure below?



- A. Amine
B. Alcohol
C. Ester
D. Alkene

Question 16

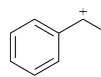
Count the number of stereocenters in the structure below.



- A. 5
B. 6
C. 7
D. 8

Question 17

Which carbocation is the most stable?



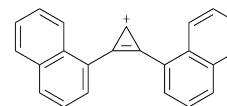
A



B



C



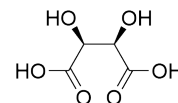
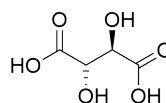
D

- A. A
B. B
C. C
D. D

Question 18

Consider the following compounds.

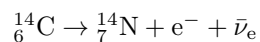
Which of the following is true?



- A. They are a pair of enantiomers.
B. They are a pair of diastereomers.
C. They are a pair of *E/Z* isomers.
D. They are identical compounds.

Question 19

Carbon-14 is a radioactive isotope constantly produced in high atmosphere. This isotope is introduced in the biogeochemical carbon cycle. The concentration of this isotope is important for datation of organic material. Its radioactive decay is described with the following equation:

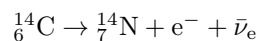


Which type of radioactive decay is shown in the equation above?

- A. α -decay
B. β^+ -decay
C. β^- -decay
D. γ -decay

Question 20

Knowing that the radioactive decay of Carbon-14 as shown below is a first-order reaction, choose the corresponding rate law for the reaction.



- A. $v = k[{}^{14}\text{N}]$
 B. $v = k[{}^{14}\text{N}]^2$
 C. $v = k[{}^{14}\text{C}]$
 D. $v = k[{}^{14}\text{C}]^2$

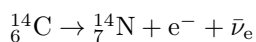
Question 21

Radioactive decay in general is described by the equation:

$$N(t) = N_0 e^{-kt},$$

where $N(t)$ is the number of radioactive atoms remaining at time t , N_0 is the initial number of atoms, and k is the decay constant.

Considering the following reaction:



and that the half-life of carbon-14 is 5734 years, calculate the decay constant k .

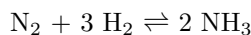


- A. $k = 7.67 \cdot 10^{-12} \text{ s}^{-1}$
 B. $k = 2.61 \cdot 10^{-12} \text{ s}^{-1}$
 C. $k = 1.21 \cdot 10^{-4} \text{ s}^{-1}$
 D. $k = 3.83 \cdot 10^{-12} \text{ s}^{-1}$

Question 22

The Haber–Bosch process is a key industrial method for the synthesis of ammonia, playing a central role in nitrogen fixation, which is essential for plant growth. The production of ammonia is fundamental to the development of fertilizers.

The overall chemical reaction for this process is:



Additionally, important thermodynamic constants are given in the table.

Calculate the Gibbs free energy $\Delta_r G^\circ$ for this reaction at standard conditions ($T = 298 \text{ K}$ and $p = 1.00 \text{ bar}$).

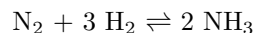
Is the following reaction spontaneous or not?

	N_2	H_2	NH_3
$\Delta_f H^\circ [\text{kJ mol}^{-1}]$	0	0	-49.5
$S^\circ [\text{J mol}^{-1} \text{ K}^{-1}]$	191.61	130.68	192.77

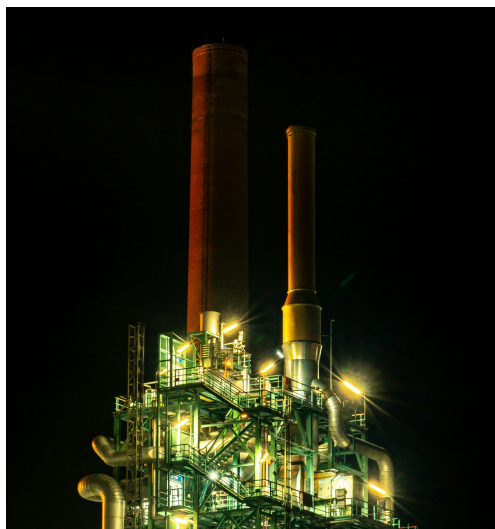
- A. $\Delta_r G^\circ = -7.3 \text{ kJ}\cdot\text{mol}^{-1}$, the reaction is spontaneous
 B. $\Delta_r G^\circ = -7.3 \text{ kJ}\cdot\text{mol}^{-1}$, the reaction is not spontaneous
 C. $\Delta_r G^\circ = -32.76 \text{ kJ}\cdot\text{mol}^{-1}$, the reaction is spontaneous
 D. $\Delta_r G^\circ = 58944 \text{ kJ}\cdot\text{mol}^{-1}$, the reaction is not spontaneous

Question 23

In which conditions will you perform the reaction below in order to increase the yield of the reaction and push the equilibrium to the side of the product?



- (1) High pressure and high temperature
 (2) High pressure and low temperature
 (3) Low pressure and high temperature
 (4) Using an excess of one of the reactants

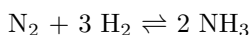


- A. (2) and (4)
 B. (1) and (4)
 C. (2)
 D. (3)

Question 24

Considering the overall reaction for the production of ammonia as shown below as a pure redox reaction in standard conditions, we assume that the reaction has a redox potential of $E^\circ = +0.092$

V.



Calculate $\ln(K)$ for this reaction, where K is the equilibrium constant.

Consider $T = 298.15 \text{ K}$, $F = 96500 \text{ C}\cdot\text{mol}^{-1}$, $R = 8.314 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$.

- A. $\ln(K) = 1$
- B. $\ln(K) = 3.58$
- C. $\ln(K) = 10.74$
- D. $\ln(K) = 21.48$

Question 25

Calculate the pH of a solution containing $0.2 \text{ mol}\cdot\text{L}^{-1}$ of CuSO_4 .

($\text{pK}_{a2}(\text{H}_2\text{SO}_4) = 1.92$)



- A. 6.4
- B. 7.6
- C. 10.1
- D. 12.7

Question 26

You want to prepare 1 L of buffer solution with $\text{pH} = 9.02$ with NH_3 and NH_4Cl .

($M = 53.49 \text{ g}\cdot\text{mol}^{-1}$, $\text{pK}_a = 9.22$) The solution already contains $0.1 \text{ mol}\cdot\text{L}^{-1}$ of NH_3 .

Which mass of NH_4Cl do you have to add to the solution to reach the desired pH?

- A. 0.16 g
- B. 3.15 g
- C. 3.37 g
- D. 8.48 g

Question 27

For which proposition are the acids arranged from strongest to weakest in aqueous solution?

- A. $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$
- B. $\text{HCl} > \text{HF} > \text{HBr} > \text{HI}$
- C. $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$
- D. $\text{HF} = \text{HBr} = \text{HCl} = \text{HI}$

Question 28

Barium sulfate is a sparingly soluble salt with a solubility constant (K_{sp}) of $1.1 \cdot 10^{-10}$.

What is the molar solubility of BaSO_4 in pure water?

- A. $1.05 \cdot 10^{-5} \text{ mol}\cdot\text{L}^{-1}$
- B. $1.05 \cdot 10^{-7} \text{ mol}\cdot\text{L}^{-1}$
- C. $1.05 \cdot 10^{-8} \text{ mol}\cdot\text{L}^{-1}$
- D. $1.05 \cdot 10^{-10} \text{ mol}\cdot\text{L}^{-1}$

Question 29

When adding zinc sulfate to a barium sulfate solution, what happens to the solubility of barium sulfate and why?

- A. It increases because Zn^{2+} removes SO_4^{2-} by forming a precipitate
- B. It decreases because SO_4^{2-} from ZnSO_4 shifts the equilibrium toward solid BaSO_4
- C. It stays the same because Zn^{2+} doesn't react with Ba^{2+}
- D. It increases because the added Zn^{2+} increases the total ion concentration

Question 30

At 25°C , the solubility of sodium acetate in water is 36.5 g per 100 mL.

What is the molarity of a saturated sodium acetate solution at 25°C ?

- A. $1.45 \text{ mol}\cdot\text{L}^{-1}$
- B. $4.4 \text{ mol}\cdot\text{L}^{-1}$
- C. $7.29 \text{ mol}\cdot\text{L}^{-1}$
- D. $14.51 \text{ mol}\cdot\text{L}^{-1}$

Question 31

A sodium acetate crystal is added to a supersaturated solution of sodium acetate, what happens?

- A. The crystal floats on the solution
- B. The crystal dissolves

- C. The crystal sinks
- D. Additional crystals form

Question 32

For some compounds, the energy released by the hydration of the ions is significantly different from the energy consumed by the breaking of the ionic lattice.

For calcium chloride, the hydration energy is significantly higher than the lattice energy.

What happens when calcium chloride is dissolved in water and why?



- A. The solution becomes cold because the dissolution is exothermic.
- B. The solution becomes cold because the dissolution is endothermic.
- C. The solution becomes hot because the dissolution is exothermic.
- D. The solution becomes hot because the dissolution is endothermic.

Question 33

Transition metals like copper, zirconium and iridium often form coloured compounds.

What is responsible for this property?



- A. They have partially filled s-orbitals.
- B. They have filled p-orbitals.
- C. They have partially filled d-orbitals.
- D. They have empty f-orbitals.

Question 34

Ice is less dense than water. What causes this?



- A. The van-der-Waals forces in liquid water.
- B. Gas enclosures within the crystal.
- C. The hydrogen bonding network within the crystal.
- D. Ice loses mass due to sublimation.

Question 35

Sodium reacts vigorously upon contact with water, potassium reacts even more vigorously. Why?



- A. Potassium has fewer protons, meaning its electrons are more reactive.
- B. Potassium has a lower ionization energy.
- C. Sodium is larger, making it more robust.
- D. Sodium forms a protective layer, slowing the reaction.

Question 36

Calcium is essential in biological systems such as bones and muscles.

What property makes its structural role in bones possible?



- A. Its variable oxidation state.
- B. Being a soft metal.
- C. Forming insoluble phosphate salts.
- D. Covalent bond formation with carbon.

Question 37

Iron rusts in moist air. But what is the name of

the responsible chemical process?



- A. Acid-base reaction
- B. Substitution
- C. Redox reaction
- D. Hydrolysis