

**CHEMISTRY.
OLYMPIAD.CH**

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15th Swiss and Liechtenstein Chemistry Olympiad

First round

Multiple Choice	: 30 Questions
Duration	: 40 minutes
Questions	: Multiple Choice Questions (MC) and Multiple True False Questions (MTF)
Grading	: Each fully correct reply is worth one point.
Aids and tools	: All aids are allowed (Text books, calculators, periodic table, etc.). However, the test has to be solved on one's own without the help from others.
Participation conditions (according to IChO)	: - born after 1 st of July 2001 - not yet immatriculated at an university - attending a Swiss school (now or previously)
Due date	: 26 th of September 2020
Due address	: available online

Good luck!

Question 1 (MC):

To gain precipitated silver chloride (solid) from an aqueous solution, which of the following extraction methods will likely be the most successful?

- A Crystallization
- B Column chromatography
- C Centrifugation
- D Fractional distillation
- E Using a strong magnet

Question 2 (MC):

Cobalt has only one naturally occurring isotope. What mass does one single cobalt atom have?

- A 5.9×10^{-22} g
- B 9.8×10^{-23} g
- C 3.5×10^{-25} g
- D 4.5×10^{-23} g
- E 1.6×10^{-21} g

Question 3 (MC):

What is the basic composition of $^{75}_{33}\text{As}$?

- A 33 protons, 42 neutrons, and 33 electrons.
- B 75 protons, 42 neutrons, and 75 electrons.
- C 33 protons, 75 neutrons, and 33 electrons.
- D 33 protons, 108 neutrons, and 33 electrons.
- E 33 protons and 75 electrons but neutrons cannot be determined.

Question 4 (MC):

What is the name of the following compound: P_4S_7 ?

- A Phosphoro-IV-sulfide-VII
- B Tetraphosphorus heptasulfide
- C Quatrophosphorous septimosulfide
- D Tetraphosphoheptasulfite
- E Phosphorus[IV] sulfide[VII]

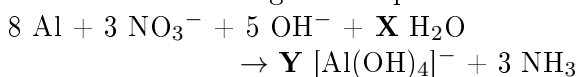
Question 5 (MC):

Which one of the following best describes the molecular geometry (shape) of SeF_3^+ ?

- A Tetrahedral
- B Trigonal-pyramidal
- C Trigonal-planar
- D Bent
- E Cyclic

Question 6 (MC):

Given is the following redox equation:



Determine **X** and **Y**.

- A **X** = 9; **Y** = 4
- B **X** = 15; **Y** = 8
- C **X** = 0; **Y** = 8
- D **X** = 8; **Y** = 4
- E **X** = 18; **Y** = 8

Question 7 (MC):

Which is the oxidation number of Te in H_6TeO_6 ?

- A +IV
- B +VI
- C -VI
- D 0
- E +XII

Question 8 (MC):

Having 0.250 mol N_2 gas in a container (10 L) at 100 °C. Using the ideal gas law, calculate the corresponding pressure:

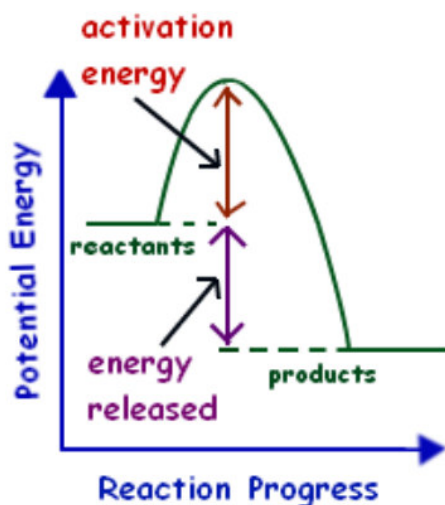
$$pV = nRT$$

$$R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1}$$

- A 20.8 kPa
- B 7.7×10^3 kPa
- C 78 kPa
- D 1.1 kPa
- E 2.8 kPa

Question 9 (MC):

Given the following diagram, which of the following statements is correct?



- A The reaction is endothermic.
- B The products have less mass than the reactants.
- C The reaction emits light (fluorescence).
- D The reaction is exothermic.
- E The reaction is gravity-sensitive.

Question 10 (MC):

Ethanoic acid and ethanol react reversibly to form ethyl ethanoate and water. This reaction is fairly slow, and is usually done in the presence of a small amount of concentrated sulphuric acid as a catalyst. What is the effect on the equilibrium when adding the catalyst?

- A Shift to the educt side, because there are more reactants.
- B Shift to the product side, because the catalyst makes the reaction faster.
- C Shift to the product side, because sulphuric acid reacts with water.
- D Shift to educt side, because more acid is added.
- E No effect on the equilibrium, as a catalyst only speeds up a reaction.

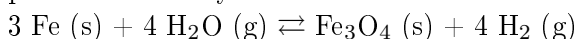
Question 11 (MC):

Why do N_2 and O_2 both co-exist in the air and do not react to NO ?

- A Because same-element-gases are preferred according to the Borsch-Nigel-Law.
- B Because NO immediately explodes in sunlight.
- C Because the equilibrium at room temperature is on the left side (favouring N_2 and O_2).
- D Because there is too much N_2 and not enough O_2 in the air.
- E Because humans need oxygen to survive.

Question 12 (MC):

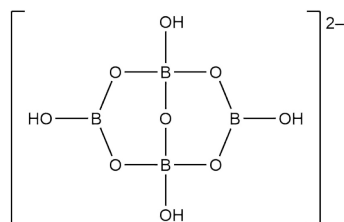
Iron is oxidized with water in a closed system. What is the effect on the equilibrium if the pressure in the system is increased?



- A Shift to the left because hydrogen gas is being compressed.
- B Shift to the right because concentrations of the involved gases increase.
- C Shift to the right because particles are in closer contact to react.
- D No effect on the equilibrium, as iron also acts as a catalyst in this reaction.
- E No effect on the equilibrium, as there is no change in volume in this reaction.

Question 13 (MC):

Which is the correct empirical formula of the following structure?



- A $(\text{BOH})_4\text{O}_5^{2-}$
- B $\text{O}(\text{BOH})_2[(\text{OBO}(\text{OH}))_2]^{2-}$
- C $\text{B}_4\text{O}_9\text{H}_4^{2-}$
- D $[\text{B}_4\text{O}_5(\text{OH})_4]^{2-}$
- E This molecule does not exist.

Question 14 (MC):

Which is the conjugated base of SH^- ?

- A S^{2-}
- B HS
- C S^-
- D H_2S
- E HS^+

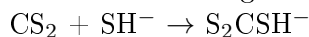
Question 15 (MC):

Which is the conjugated acid of SH^- ?

- A HS
- B S^0
- C H_2S^-
- D $\text{H}^- \text{S}$
- E H_2S

Question 16 (MC):

Given the following reaction:



According to Lewis, which compound acts as base and which as acid?

- A CS_2 is the base and SH^- is the acid.
- B SH^- is the base and CS_2 is the acid.
- C CS_2 is both base and acid.
- D SH^- is both base and acid.
- E CS_2 is the acid and SH^- acts as a catalyst.

Question 17 (MC):

To a 100 mL solution of 0.035 mol/L HNO_2 (nitrous acid), 0.010 mol NaNO_2 (sodium nitrite) are added. What is the pH value of that solution?

$$\text{pK}_a(\text{HNO}_2) = 3.29$$

$$\text{pH} = \text{pK}_a + \log_{10} \left[\frac{[\text{A}^-]}{[\text{HA}]} \right]$$

- A 1.46
- B 2.75
- C 2.83
- D 3.75
- E 3.83

Question 18 (MC):

How many constitutional isomers are there of $\text{C}_4\text{H}_{11}\text{N}$?

Double bond equivalences for $\text{C}_c\text{H}_h\text{N}_n$:

$$\text{DBE} = \frac{2c - h + n + 2}{2}$$

- A 4
- B 5
- C 6
- D 7
- E 8

Question 19 (MC):

Carbon dating is a method that can be used to determine the age of fossil remains. It uses the radioactive carbon isotope ^{14}C with a half-life of approximately 5'700 years. If 15 % of the initial amount of ^{14}C in a sample remain, how much time has elapsed?

$$N(t) = N_0 \exp(-kt)$$

$$t_{1/2} = \frac{\ln(2)}{k}$$

- A 855 years
- B 5'700 years
- C 15'600 years
- D 21'800 years
- E 54'200 years

Question 20 (MC):

How much energy gets released at the nuclear fission of 1 kg uranium-235?



$$m(\text{n}) = 1.0087 \text{ u}$$

$$m(^{90}\text{Kr}) = 89.9252 \text{ u}$$

$$m(^{143}\text{Ba}) = 142.9267 \text{ u}$$

$$m(^{235}\text{U}) = 235.0439 \text{ u}$$

$$E = mc^2$$

$$c = 299'792'458 \text{ m/s}$$

$$1 \text{ u} = 1.66054 \times 10^{-27} \text{ kg}$$

A 0.175 J

B 4190 J

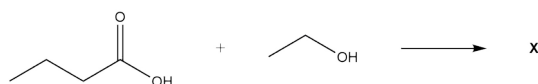
C 8380 J

D $5.43 \times 10^6 \text{ J}$

E $6.66 \times 10^{13} \text{ J}$

Question 21 (MC):

What is the name of the product of this condensation reaction?



A X = pentan-2-one

B X = hexan-3-one

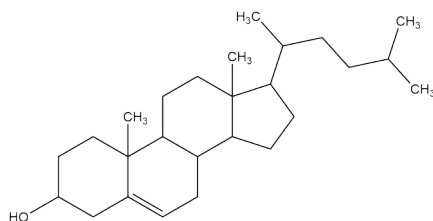
C X = methyl butanoate

D X = ethyl butanoate

E X = 2-hydroxyethyl butanoate

Question 22 (MC):

How many chiral centers are there in the structure below?



A 0

B 3

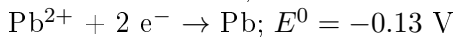
C 5

D 8

E 10

Question 23 (MC):

What is the cell potential of a galvanic cell based on the following reduction half-reactions at 25 °C, where $[\text{Ni}^{2+}] = 0.20 \text{ M}$ and $[\text{Pb}^{2+}] = 0.02 \text{ M}$?



$$E = E^0 + \frac{RT}{nF} \ln \frac{[\text{Ox}]}{[\text{Red}]}$$

$$R = 8.3145 \text{ J mol}^{-1} \text{ K}^{-1}; F = 96485 \text{ C mol}^{-1}$$

A -13 mV

B -70 mV

C +70 mV

D +100 mV

E +130 mV

Question 24 (MC):

What is the maximum yield of ammonia if 3 g hydrogen gas react with 1 g nitrogen gas?

A 0.61 g

B 1.2 g

C 4.0 g

D 26 g

E 51 g

Question 25 (MC):

Ag_2CrO_4 has a solubility product of $1.1 \times 10^{-12} \text{ mol}^3 \text{ L}^{-3}$ at 25 °C. What mass of silver chromate can be dissolved in 2 L of water?

$$K_L = [\text{Ag}^+]^2 [\text{CrO}_4^{2-}]$$

A 19 μg

B 27 μg

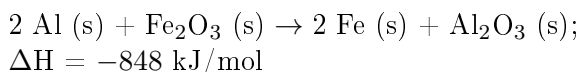
C 6.5 mg

D 22 mg

E 43 mg

Question 26 (MC):

The reaction of aluminium with iron oxide is strongly exothermic and can reach temperatures up to 2400 °C. Therefore, the thermite reaction is often used to join railway tracks. How much heat is generated if 100 g of aluminium is reacted with excess iron oxide?



- A 785 kJ
- B 848 kJ
- C 1570 kJ
- D 3140 kJ
- E 7340 kJ

Question 27 (MC):

Rank these compounds in terms of increasing acidity: $\text{CH}_3\text{CO}_2\text{H}$, HCl , HClO_4 , H_2O and H_2S .

- A $\text{H}_2\text{O} < \text{H}_2\text{S} < \text{CH}_3\text{CO}_2\text{H} < \text{HCl} < \text{HClO}_4$
- B $\text{H}_2\text{O} < \text{CH}_3\text{CO}_2\text{H} < \text{H}_2\text{S} < \text{HCl} < \text{HClO}_4$
- C $\text{H}_2\text{S} < \text{H}_2\text{O} < \text{CH}_3\text{CO}_2\text{H} < \text{HCl} < \text{HClO}_4$
- D $\text{H}_2\text{S} < \text{H}_2\text{O} < \text{CH}_3\text{CO}_2\text{H} < \text{HClO}_4 < \text{HCl}$
- E $\text{H}_2\text{O} < \text{CH}_3\text{CO}_2\text{H} < \text{H}_2\text{S} < \text{HClO}_4 < \text{HCl}$

Question 28 (MC):

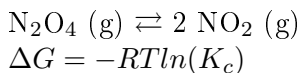
Which energy has a single quantum of yellow light of wavelength 550 nm?

$$E = hf = h \frac{c}{\lambda}$$
$$h = 6.626 \times 10^{-34} \text{ J s}$$
$$c = 299'792'458 \text{ m/s}$$

- A $3.6 \times 10^{-19} \text{ J}$
- B $3.6 \times 10^{-28} \text{ J}$
- C $1.2 \times 10^{-31} \text{ J}$
- D $3.6 \times 10^{-40} \text{ J}$
- E $1.2 \times 10^{-48} \text{ J}$

Question 29 (MC):

The equilibrium constant of the decomposition reaction of N_2O_4 to two equivalents of NO_2 at 25 °C was found to be $K_c = 4.66 \times 10^{-3} \text{ mol/L}$. Calculate the free Gibbs energy of this reaction:



- A 485 J/mol
- B 1.12 kJ/mol
- C 5.78 kJ/mol
- D 13.3 kJ/mol
- E 22.4 kJ/mol

Question 30 (MTF):

Consider the following statements that compare pure metals and alloys. Which statements are correct?

- A Gold is a better conductor than red gold (gold and copper alloy).
- B Gold is more ductile than red gold (gold and copper alloy).
- C Alloys are not homogenous mixtures.
- D Pure metals generally find a wider variety of applications (construction, automobile, surgical tools, ...) than alloys.
- E Iron-based alloys with chromium are far less prone to rust than pure iron.