14th Swiss and Liechtenstein Chemistry Olympiad

First round

Multiple Choice : 25 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 : - born on or after 1st of Juli 2000 - not yet immatriculated at an university - attending a Swiss school (now or previously)
Due date : 27th of Oktober 2019
Due address : available online

Good luck!
Question 1 (MC):
What is the concentration of a polymer solution in mg mL\(^{-1}\), assuming a concentration of 382 \(\mu\)M and a molecular weight of 33116 g mol\(^{-1}\)?
A 7 mg mL\(^{-1}\)
B 17 mg mL\(^{-1}\)
C 10 mg mL\(^{-1}\)
D 1.7 mg mL\(^{-1}\)
E 13 mg mL\(^{-1}\)

Question 2 (MC):
What is the pH value of an aqueous HClO\(_4\) solution at a concentration of 0.0457 mol/L?
A 2.84
B 1.84
C 1.34
D I cannot determine the pH value as I am missing the pK\(_a\) value.
E 0.34

Question 3 (MC):
A protein is quantified via the lambert-beer law \((A = \epsilon \cdot l \cdot c)\). The extinction coefficient of said protein is 78565 M\(^{-1}\) cm\(^{-1}\) at 280 nm. We measure an absorbance of \(A = 0.300\) for a 1 : 100 diluted sample, measured at 280 nm and with an optical path length of 5 mm. What is the initial protein concentration of our sample?
A 5.12 \(\mu\)M
B 764 \(\mu\)M
C 206 \(\mu\)M
D 124 \(\mu\)M
E 512 \(\mu\)M

Question 4 (MC):
The CN\(^-\) ion has a pK\(_B\) value of 4.78. What is the pH value of a 0.005 M solution of HCN?
A 5.76
B 3.04
C 3.54
D 10.46
E 8.24

Question 5 (MTF):
Americium-241 (\(^{241}_{95}\)Am) is an alpha emitter and was therefore commonly used in smoke detectors. What are the products of the alpha decay?
A \(^{3}\)He
B \(^{234}_{91}\)Pa
C \(^{239}_{94}\)Pu
D \(^{239}_{93}\)Np
E \(^{237}_{93}\)Np

Question 6 (MC):
If we have a sample of 5.0 g \(^{241}_{95}\)Am today, how much would be left in 300 years (half-life = 432.2 a)?
A 1.8 g
B 4.2 g
C 8.1 g
D 3.1 g
E 2.5 g

Question 7 (MC):
The electron configuration \((1s)^2(2s)^2(2p)^4\) corresponds to which element?
A C
B S
C N
D P
E O
Question 8 (MC):
How many electrons are transferred in the oxidation/reduction between \( \text{I}_2\text{O}_5 \) and I\(_2\) in the following redox reaction?

\[
\text{I}_2\text{O}_5 + 5 \text{CO} \rightarrow \text{I}_2 + 5 \text{CO}_2
\]

A 6
B 10
C 4
D 2
E 12

Question 9 (MC):
The following reaction is used to quantify carbon monoxide. What is the volume of CO\(_2\) evolved by letting one liter of air react with \( \text{I}_2\text{O}_5 \), if we assume that the level of CO in air is 0.2 ppm (assuming atmospheric pressure)?

\[
\text{I}_2\text{O}_5 + 5 \text{CO} \rightarrow \text{I}_2 + 5 \text{CO}_2
\]

A 0.2 L
B 1 \( \mu \)L
C 0.2 \( \mu \)L
D 0.001 cm\(^3\)
E 0.0002 L

Question 10 (MC):
Which of these molecules show the same oxidation state at the indicated carbon?

\[
\text{A 1 + 5}
\text{B 4 + 5}
\text{C 1 + 2}
\text{D 1 + 4}
\text{E 1 + 3}
\]

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Question 11 (MTF):
Which of the following elements occurs as a liquid at 20 °C and atmospheric pressure?

A Be
B Hg
C Cl
D Br
E F

Question 12 (MTF):
Which molecule show a trigonal pyramidal conformation?

A \( \text{NH}_3 \)
B \( \text{NO}_3^- \)
C \( \text{PCl}_3 \)
D \( \text{SO}_3^{2-} \)
E \( \text{BH}_3 \)

Question 13 (MC):
Order the following molecules according to their boiling point.

\[
\begin{align*}
\text{A 4} & < \text{2} & < \text{3} & < \text{5} & < \text{1} \\
\text{B 3} & < \text{2} & < \text{4} & < \text{1} & < \text{5} \\
\text{C 5} & < \text{1} & < \text{3} & < \text{2} & < \text{4} \\
\text{D 5} & < \text{1} & < \text{4} & < \text{2} & < \text{3} \\
\text{E 4} & < \text{2} & < \text{3} & < \text{1} & < \text{5}
\end{align*}
\]
Question 14 (MC):
Calculate the reaction enthalpy of the following reaction and make a statement whether the reaction is endothermic or exothermic. Consider:
\[ \Delta_f H(\text{Glucose, } s) = -1260 \text{ kJ mol}^{-1} \]
\[ \Delta_f H(\text{H}_2\text{O, } g) = -242 \text{ kJ mol}^{-1} \]
\[ \Delta_f H(\text{CO}_2, g) = -393 \text{ kJ mol}^{-1} \]
\[ \text{C}_6\text{H}_{12}\text{O}_6 (s) + 6 \text{ O}_2 (g) \rightarrow 6 \text{ CO}_2 (g) + 6 \text{ H}_2\text{O (g)} \]

A  \( \Delta_r H = -2550 \text{ kJ mol}^{-1} \), exothermic
B  \( \Delta_r H = +5070 \text{ kJ mol}^{-1} \), exothermic
C  \( \Delta_r H = -2550 \text{ kJ mol}^{-1} \), endothermic
D  \( \Delta_r H = +2550 \text{ kJ mol}^{-1} \), endothermic
E  \( \Delta_r H = +2550 \text{ kJ mol}^{-1} \), exothermic

Question 15 (MC):
In order to determine the heat generated by a reaction, one uses a calorimeter. A calorimeter uses a reference cell filled with 0.4 L of water. The heat generated is determined from the increase in temperature and the heat capacity of water (4.18 J g\(^{-1}\) K\(^{-1}\)). If we assume that the last reaction run in our calorimeter heated the water from 37 °C to 48 °C. How much energy did the reaction generate?
A  18.4 J
B  1.84 kJ
C  18400 J
D  46 kJ
E  46 J

Question 16 (MC):
Below you can see the titration curve of ammonia with HCl. What is the \( pK_a \) of the ammonium ion?

![Titration Curve]

A  I am not given enough information to answer this Question.
B  9.2
C  5.0
D  8.4
E  1.0

Question 17 (MC):
You are working up a reaction and your product shows a distribution coefficient of \( 4 = \frac{c(\text{EtOAc})}{c(\text{H}_2\text{O})} \). If you extract your aqueous phase (100 mL) three times with EtOAc (100 mL each). What is the percentage of product in the combined organic phase?
A  96
B  80
C  95
D  91
E  99
Question 18 (MTF):
Choose all statements which are correct.
A NaCl (s) is a good electrical conductor.
B The electrical conductivity of a NaCl solution in water decreases with increasing temperature.
C The electrical conductivity of metals increases with increasing temperature.
D NaCl (aq) is a good electrical conductor.
E NaCl (l) is a good electrical conductor.

Question 19 (MTF):
Which of the following functional groups is not present in the given molecule?

A Double bond
B Amine
C Amide
D Alcohol
E Ester

Question 20 (MTF):
Which of the following molecules is not a constitution isomer of C₄H₈O?

A 3
B 4
C 5
D 2
E 1

Question 21 (MC):
What is the energy of a photon of wavelength 350 nm? Consider the formula \( E = \frac{hc}{\lambda} \) Planck’s constant is \( h = 6.626 \cdot 10^{-34} \) J s and the speed of light in a vacuum is \( c = 2.998 \cdot 10^8 \) m s⁻¹.
A 5.7 \cdot 10^{-19} \) J
B 5.7 \cdot 10^{19} \) J
C 5.7 \cdot 10^{-16} \) J
D 5.7 \cdot 10^{18} \) J
E 5.7 \cdot 10^{-18} \) J

Question 22 (MC):
How many atoms of Einsteinium, \(^{254}\text{Es}\), are in a sample of 0.5 g?
A 1.29 \cdot 10^{21}
B 3.04 \cdot 10^{22}
C 1.19 \cdot 10^{21}
D 3.04 \cdot 10^{21}
E 1.29 \cdot 10^{22}

Question 23 (MC):
How many Ag⁺ ions are present in 0.5 L of a saturated AgCl solution (\( K_L = 2.0 \cdot 10^{-10} \) M²)?
A 1.00 \cdot 10^{-5} \) mol
B 7.07 \cdot 10^{-5} \) mol
C 1.41 \cdot 10^{-6} \) mol
D 7.07 \cdot 10^{-6} \) mol
E 1.41 \cdot 10^{-7} \) mol

Question 24 (MC):
Order the following elements according to their electronegativity in increasing order.
A P < Na < C < O < F
B Na < P < C < O < F
C Na < C < P < O < F
D Na < C < P < F < O
E Na < P < C < F < O
**Question 25 (MC):**

We measured a property B of a solution to be 3.45 what was the solution's concentration if you consider the following plot?

![Plot with concentration vs. property B]

A 0.09 µM  
B 0.18 µM  
C 0.9 µM  
D 0.045 µM  
E 4.5 µM