CHEMISTRY.
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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 (according to IChO)	:	- 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 μM 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 coeficient of said protein is 78′565 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 μM
B 764 μM
C 206 μM
D 124 μM
E 512 μM

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 $^{4}_{2}He$
B $^{234}_{91}Pa$
C $^{240}_{94}Pu$
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 I_2O_5 and I_2 in the following redox reaction?

$$I_2O_5 + 5\ CO \rightarrow I_2 + 5\ CO_2$$

A 6
B 10
C 4
D 2
E 12

Question 9 (MC):

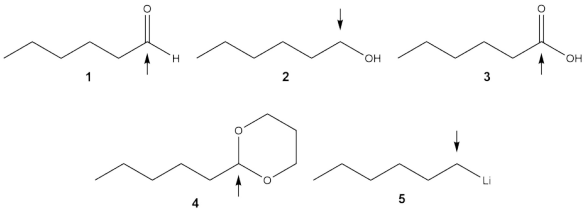
The following reaction is used to quantify carbon monoxide. What is the volume of CO_2 evolved by letting one liter of air react with I_2O_5, if we assume that the level of CO in air is 0.2 ppm (assuming atmospheric pressure)?

$$I_2O_5 + 5\ CO \rightarrow I_2 + 5\ CO_2$$

A 0.2 L
B 1 μL
C 0.2 μL
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?



A 1 + 5
B 4 + 5
C 1 + 2
D 1 + 4
E 1 + 3

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

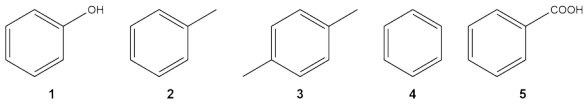
Question 12 (MTF):

Which molecule show a trigonal pyramidal conformation?

A NH_3
B NO_3^-
C PCl_5
D SO_3^{2-}
E BH_3

Question 13 (MC):

Order the following molecules according to their boiling point.



A 4 < 2 < 3 < 5 < 1
B 3 < 2 < 4 < 1 < 5
C 5 < 1 < 3 < 2 < 4
D 5 < 1 < 4 < 2 < 3
E 4 < 2 < 3 < 1 < 5

Question 14 (MC):

Calculate the reaction enthalpy of the following reaction and make a statement whether the reaction is endothermic or exothermic. Consider:
$\Delta_f H(\text{Glucose}, s) = -1260$ kJ mol^{-1}
$\Delta_f H(H_2O, g) = -242$ kJ mol^{-1}
$\Delta_f H(CO_2, g) = -393$ kJ mol^{-1}

$$C_6H_{12}O_6\,(s) + 6\,O_2\,(g) \rightarrow 6\,CO_2\,(g) + 6\,H_2O\,(g)$$

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

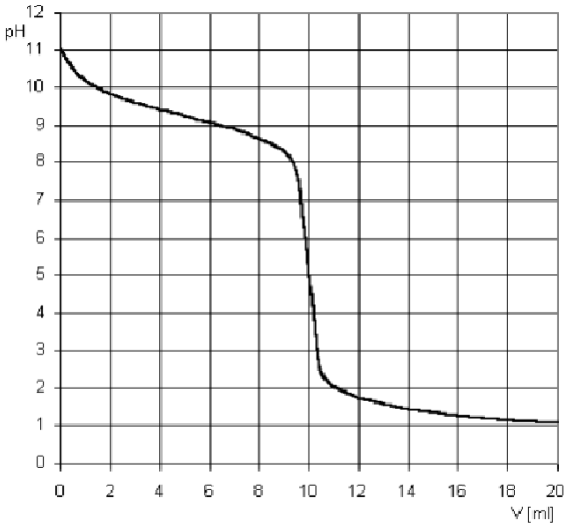
Question 15 (MC):

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?



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 $4 = \frac{c(\text{EtOAc})}{c(H_2O)}$. 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.

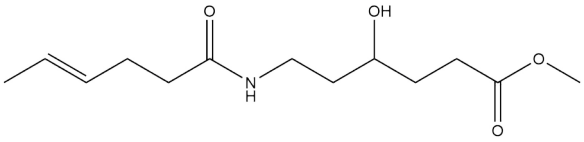
C The electrical conductivity of metals increases with increasing temperature.

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

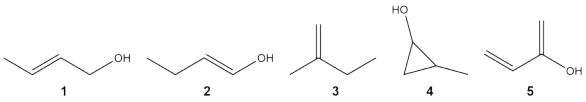
C Amide

D Alcohol

E Ester

Question 20 (MTF):

Which of the following molecules is not a constitution isomer of C_4H_8O?



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, $^{254}_{99}$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 ($K_L = 2.0 \cdot 10^{-10}$ M^2)?

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

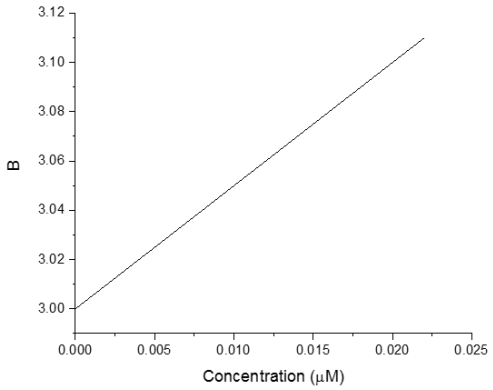
C Na < C < P < O < F

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 solutions concentration if you consider the following plot?



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