MOCK EXAM – CH100
2025

Single-choice questions (2.5 points each)

Notes:

- In the real exam, the questions will also be translated in French. You are allowed to answer to the open questions in French, if easier.
- You need to only pick the one correct answer. Picking more than one gives you 0 for that question.
- You do not need to provide the calculation for the answers to be admissible for the single choice questions

1. Indicate, from the following list, the molecule whose central atom is hybridized in sp^3
   a. CO_2
   b. BF_3
   c. $BeCl_2$
   d. SO_2
   e. CH_4
2. What is <u>not correct</u> about H_2O?
   a. The oxygen atom has 2 lone pairs of electrons
   b. The oxygen atom undergoes sp^3 hybridization
   c. The molecular geometry of the molecule is planar
   d. The electron geometry is tetrahedral
   e. The molecular geometry is the molecule is bent
3. Which of the configurations below cannot exist?
   a. $1s^2\ 2s^2\ 2p^6\ 3s^1$
   b. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
   c. $1s^2\ 2s^2\ 2p^7$
   d. $1s^2\ 2s^2\ 2p^4$
   e. $1s^1$
4. Which element with a <u>2+ charged ion</u> has the following configuration: [Ar]
   a. Be
   b. Mg
   c. Ca
   d. Sr
   e. Ba
5. 1. At room temperature, what is the value of the molar heat capacity at constant pressure for oxygen?
   a. 3/2 R
   b. 5/2 R
   c. 7/2 R
   d. 3 R
6. What is the balanced reaction of Calcium carbonate with sulfuric acid?
   a. $CaCO_3\ (s)+H_2SO_4(aq)\rightarrow CaSO_4\ (s)+CO_2(g)+H_2O(l)$
   b. $CaSO_4 + H_2O\rightarrow CaO+ H_2SO_4$
   c. $CaCO_3\ (s)+H_2SO_3(aq)\rightarrow CaSO_3\ (s)+CO_2(g)+H_2O(l)$
   d. $3\ CaCO_3\ (s)+2\ H_3PO_4(aq)\rightarrow Ca_3(PO_4)_2(s)+ 3\ CO_2(g)+ 3\ H_2O(l)$

7. An elastic balloon (no gas exchange/escape) has a volume of 300 L at 25°C, 1 atm, and sea level. What is the volume of that balloon at 5000 m? Assume a standard

tropospheric lapse rate (−6.5 K per km) for the temperature decrease and an atmospheric pressure of 0.54 atm at 5000 m.

a. 290 L
b. 390 L
c. 490 L
d. 590 L

8. 4. Calculate the work when carbon monoxide expands reversibly from 5 to 1 atm at 25°C. (Treat carbon monoxide as an ideal gas.)
   a. -20 kJ
   b. -10 kJ
   c. 10 kJ
   d. 20 kJ

9. In the table below, you will find several examples of weak acids with either their K_a or the K_b of their conjugate base, measured in water at 25 °C. Rank the acids starting from the strongest to the weakest.

Acid label	K_a	K_b (of conjugate base)
A1		9.35×10^{-12}
A2	7.08×10^{-8}	
A3	6.31×10^{-5}	
A4		1.00×10^{-4}

Note: You do not need to complete the missing values in the table for your answer to be accepted; however, you may do so if it helps you.

a. A4 → A2 → A3 → A1
b. A3 → A2 → A1 → A4
c. A4 → A3 → A2 → A1
d. A1 → A3 → A2 → A4

10. Consider the galvanic cell with this overall reaction:

$$\mathbf{Fe^{2+}(aq) + Ag^{+}(aq) \rightleftarrows Fe^{3+}(aq) + Ag(s)}$$

The cell has a standard electromotive force (ΔE^0) of 0.03 V, measured under standard conditions. Calculate the standard Gibbs free energy change, ΔG^0, for the electrochemical reaction in this galvanic cell.

The given values are:
F = 96485 C/mol

a. – 5.79 kJ/mol
b. + 5.79 kJ/mol
c. – 2.89 kJ/mol

d. + 2.89 kJ/mol

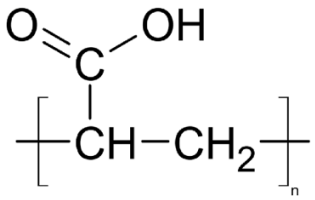
11. Consider the following first-order reaction (organic isomerization):

$$\mathbf{CH_3NC(g) \rightarrow CH_3CN(g)}$$

The initial concentration of reactant CH_3NC is 0.2 mol/L. The reaction rate constant (k) is $5.8 \times 10^{-4}\ s^{-1}$. What is the time of half-life ($t_{1/2}$), after 30 mins from the start of the reaction?

a. $t_{1/2} = 1.19 \times 10^3$ s
b. $t_{1/2} = 1.72 \times 10^3$ s
c. $t_{1/2} = 8.62 \times 10^3$ s
d. $t_{1/2} = 1.04 \times 10^4$ s

12. The polymer shown below was generated by an addition reaction:



What is the name of the precursor monomer used during the addition reaction:

a. Prop-2-enoic acid
b. Prop-1-enoic acid
c. Ethanoic acid
d. Propanoic acid

Open questions (10 points each)

Note: Please provide a step-by-step solution. Final results alone will not be eligible for full points on these questions.

A. A 25.0 mL sample of hydrochloric acid (HCl) is titrated with 0.100 M sodium hydroxide (NaOH), to form salt (NaCl) and water. It takes 30.0 mL of the NaOH solution to completely neutralize the acid.
   a. Write the balanced chemical equation for the reaction.
   b. Calculate the molarity of the HCl solution.

B. Sulfuric acid (H_2SO_4) decomposes to SO_3 and H_2O. 500 mL of a 5 M sulfuric acid solution is added to a vessel with a total volume of 20 L. The vessel is closed and heated so that the temperature is slowly rising (starting from 25°C).
   a. At which temperature is the reaction spontaneous?
   b. What is the pressure in the reaction vessel at that temperature, assuming that all the acid is decomposed?

Standard enthalpies of formation and standard entropies can be assumed constant for the calculations.

Species	**$\Delta H_f°$ (kJ/mol)**	**S° (J/(mol*K)**
SO_3 (g)	−395.77	256.8
H_2O (l)	−285.83	69.95
H_2SO_4 (l)	−814.0	157

C. Consider the reversible reaction below:

$$\mathbf{Fe^{3+}(aq) + SCN^{-}(aq) \rightleftarrows Fe(SCN)^{2+}(aq)}$$

The system is initially at equilibrium with the following concentrations:
$[Fe^{3+}] = 0.01$ mol/L ; $[SCN^-] = 0.02$ mol/L ; $[Fe(SCN)^{2+}] = 0.005$ mol/L

Their activities can be considered equal to concentrations.

The rate constants for forward and reverse reactions are:

$$k_{for} = 2500 \text{ mol } L^{-1} s^{-1} \quad ; \quad k_{rev} = 100 \ s^{-1}$$

a) The initial solution volume is 1.00 L. The solution is further diluted by adding 1.00 L of water and allowed to reach a new equilibrium. Calculate the equilibrium concentrations of all species after dilution.

b) Into the solution produced in part a), an additional 0.25 g of $Fe(SCN)^{2+}$ is dissolved, without changing the total volume. Calculate the reaction quotient (Q) immediately after this addition.

c) Assuming that each individual chemical species follows partial first-order kinetics, calculate the initial reaction rate of $Fe(SCN)^{2+}$ conversion into Fe^{3+} and SCN^- at the moment of addition (from part b).