



Chemistry Department

(1) What is the nuclear binding energy per nucleon in joules, for $^{25}_{12}\text{Mg}$ (atomic mass = 24.985839 amu, and $^1_1\text{H} = 1.007825$ amu, $^1_0\text{n} = 1.008665$ amu).
If 1 amu = 1.6605×10^{-27} kg. (c speed of light = 3×10^8 ms⁻²). (4 marks)

(2) For the reaction $\text{SbCl}_5(\text{g}) \rightleftharpoons \text{SbCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ (4 marks)

$$\Delta G^\circ_f (\text{SbCl}_5) = -334.34 \text{ kJ/mol}; \Delta G^\circ_f (\text{SbCl}_3) = -301.25 \text{ kJ/mol}$$

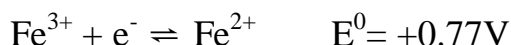
$$\Delta H^\circ_f (\text{SbCl}_5) = -394.34 \text{ kJ/mol}; \Delta H^\circ_f (\text{SbCl}_3) = -313.80 \text{ kJ/mol}$$

a. Calculate ΔG° and ΔH° at 298 K and 1 atm pressure.

b. Will this reaction proceed spontaneously at 298 K and 1 atm pressure?

c. Calculate the equilibrium constant for this reaction at 298 K.

(3) Given the followings; (4 marks)



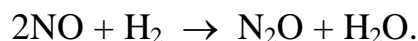
- Write the notation for the cell utilizing these half-reactions.
- Write the equation for the cell reaction.
- Calculate E° for the cell.
- Determine ΔG° .

(4) When an automobile engine starts, the metal parts immediately begin to absorb heat released during the combustion of gasoline. How much heat will be absorbed by a 165 kg iron engine block when the temperature rises from 15.7°C to 95.7°C? [The specific heat of iron is 0.489 J/g·°C.] (2 marks)

(5) The rate equation for the reaction: $\text{A} + \text{B} \rightarrow \text{P}$ is expressed in terms of [A] only. The rate of disappearance of A is $0.016 \text{ mol L}^{-1}\text{s}^{-1}$ when $[\text{A}] = 0.4 \text{ mol.L}^{-1}$. Calculate the value of k if the reaction is:

- First order in A, ii) Zero order in A. (2 marks)

(6) The data below were obtained for the reaction (4marks)



<u>Expt. #</u>	<u>[NO]_o</u>	<u>[H₂]_o</u>	<u>Initial rate</u>
1	0.021	0.065	1.46 M/min
2	0.021	0.260	1.46 M/min
3	0.042	0.065	5.84 M/min

- Determine the rate law for this reaction.
- The rate constant, k.

(7) The mass percentage of an aqueous solution of urea (CON₂H₄) is 25%.

- What is the mole fraction of urea.
- The molality of urea. (2marks)

(8) If the measured voltage of the cell (E_{cell}) Zn(s) | Zn²⁺(aq) || Ag⁺(aq) | Ag(s) is 1.37 V when the concentration of Zn²⁺ ion is 0.010 M, what is the Ag⁺ ion concentration? If E⁰_{cell} = 1.56V. (2marks)

(9) A solution that contains 13.2 g of solute in 250 g of CCl₄ freezes at -33.0 °C, if k_f CCl₄ = 29.8 °C/m and the normal freezing point of CCl₄ is -22.8 °C. Calculate the molecular weight of the solute. (3marks)

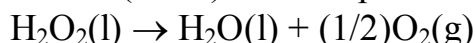
(10) The reaction: 2NO (g) → N₂ (g) + O₂ (g) is second order in NO. The rate constant is 0.286 L mol⁻¹.s⁻¹ at 1100°C and 0.500 L mol⁻¹.s⁻¹ at 1200°C. What is the activation energy of the reaction. (2marks)

(11) Aluminum metal is formed by the electrolysis of Al₂O₃ in molten cryolite.

i) How many grams of Al are produced when 6.50 × 10³ C pass through the cell?

ii) How many minutes are required to form 10.0 g of Al using a current of 30 A? (3marks)

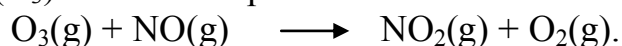
(12) Hydrogen peroxide (H₂O₂) decomposes according to the equation:



Calculate K_p for this reaction at 25°C.

$$(\Delta H^\circ = -98.2 \text{ kJ/mol}, \Delta S^\circ = 70.1 \text{ J/K}\cdot\text{mol})$$

(13) Ozone (O₃) in the atmosphere can reaction with nitric oxide (NO):



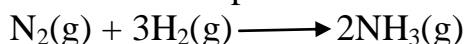
If ΔH_f for NO, NO₂ and O₃ are 90.4, 33.85, and 163.4 in kJ/mol, respectively, and S° for O₃, NO, NO₂ and O₂ are 110.9, 210.6, 240.5 and 205 in kJ/mol respectively.

Calculate: i) ΔH° , ii) ΔS° iii) ΔG° , for the above reaction.

(14) An aqueous solution of potassium nitrate made from 45.0g KNO₃ and 295 g of water. Calculate for the solution:

- i) the percent by mass of KNO₃,
- ii) molality(m)

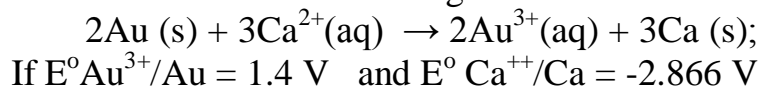
(15) Determine the equilibrium constant K_p at 25 °C for the reaction



$$[\Delta G_f^\circ \text{NH}_3(\text{g}) = -16.6 \text{ kJ/mol}]$$

(16) Benzene, C₆H₆, and Toluene, C₇H₈, form ideal solution at 60 °C, if $P_B^\circ = 0.51 \text{ atm}$. and $P_T^\circ = 0.18 \text{ atm}$. What is the vapor pressure of solution, containing 6.5g of Benzene and 23.0g of Toluene?

(17) Calculate E°_{cell} for the following reaction:



(18) The half-life of ⁹⁰Sr is 29 years. What fraction of the atoms in a sample of ⁹⁰Sr would remain 175 years later?

(19) What is the osmotic pressure of a solution that contains 13.7 g of propyl alcohol (C₃H₇OH) dissolved in enough water to make 500 mL of solution at 27°C?

(20) Consider the reaction $3\text{A}(\text{g}) \rightarrow \text{B}(\text{s}) + 3\text{C}(\text{g})$, $\Delta H^\circ = -200.0 \text{ kJ}$. Calculate the ΔE° for the reaction in kJ