



SCHOOL OF SCIENCE AND TECHNOLOGY

Semester 2, 2025

FINAL EXAMINATION PAPER

CHEF12: FOUNDATION CHEMISTRY II

Important Instructions to Students:

1. There are 11 pages. Read the questions and instructions carefully and answer the questions.
2. You are allowed an **extra 10 minutes of reading time** (during this time, you are not allowed to write with pen) and **180 minutes (3 Hours) to complete this paper.**
3. Silent, non-programmable calculators are allowed, but not supplied.
4. Write all your answers in the answer booklet provided. If you need extra sheets, please ask the supervisor. Write your name, course code and student identification number in the answer booklet and in the attendance sheet.
5. This paper contains three (3) sections A, B, and C. All questions are compulsory to answer.
6. Write all your answers legibly. Ensure that all question numbers are properly written before the answer. The marker has the right to award zero for answers that are not legible.
7. This is a **Closed Book Examination**. The University views plagiarism, cheating and dishonest practice as serious offences and if found, offenders are penalized.

Examination Paper Content (Format):

<u>Section</u>	<u>Question</u>	<u>Content</u>	<u>Marks</u>	<u>Suggested Time</u>
A	1-30	Multiple Choice	30	30 minutes
B	1-5	Short Answer Questions	50	110 minutes
C	1-2	Long Answer Questions	20	40 minutes
		TOTAL	100	180 Minutes

There are 30 multiple choice questions. All are compulsory. Write the letter of the best answer in your answer booklet.

- Which of the following processes is exothermic?
 - Melting of ice
 - Boiling of water
 - Condensation of steam
 - Evaporation of alcohol
- The unit of enthalpy change (ΔH) is:
 - Joule (J)
 - Watt (W)
 - Pascal (Pa)
 - Volt (V)
- Hess's Law is based on which scientific principle?
 - Law of conservation of energy
 - Law of multiple proportions
 - Le Chatelier's principle
 - Dalton's law
- In the Born-Haber cycle for NaCl formation, which of the following steps is exothermic?
 - Sublimation of sodium
 - Ionization of sodium
 - Electron affinity of chlorine
 - Bond dissociation of Cl_2
- Bond energy is defined as:
 - Energy required to form one mole of bonds
 - Energy required to break one mole of bonds in gaseous state
 - Energy released when one mole of bonds is broken
 - Energy released during combustion
- If the bond energy of H-H is 436 kJ/mol, breaking one mole of H_2 molecules will:
 - Absorb 436 kJ
 - Release 436 kJ
 - Absorb 218 kJ
 - Release 218 kJ
- The enthalpy change of a reaction using bond energies is calculated as:
 - Bonds broken – Bonds formed
 - Bonds formed – Bonds broken
 - Products – Reactants
 - Energy gained + Energy lost

8. At equilibrium, the rate of forward reaction is:
- Greater than reverse
 - Less than reverse
 - Equal to reverse
 - Zero
9. Which of the following affects the position of equilibrium?
- Catalyst
 - Temperature
 - Surface area
 - Stirring
10. For a saturated solution, the ionic product equals:
- Molar solubility
 - Solubility product (K_{sp})
 - Equilibrium constant (K_{eq})
 - Concentration product
11. If $Q_{sp} > K_{sp}$, a precipitate will:
- Not form
 - Dissolve completely
 - Form
 - Have no effect
12. The solubility of $AgCl$ increases when:
- $NaCl$ is added
 - NH_3 is added
 - Temperature decreases
 - $AgNO_3$ is added
13. A solution with $[H^+] = 1 \times 10^{-4} M$ has a pH of:
- 4
 - 10
 - 7
 - 14
14. The conjugate base of H_2O is:
- H_3O^+
 - OH^-
 - H^+
 - O^{2-}

15. When a strong acid reacts with a strong base, the pH at equivalence point is:
- Less than 7
 - Equal to 7
 - Greater than 7
 - Unpredictable
16. The point in titration where the number of moles of acid equals moles of base is called:
- End point
 - Equivalence point
 - Midpoint
 - Indicator point
17. If 25.0 mL of 0.1 M HCl neutralizes 25.0 mL of NaOH, the NaOH concentration is:
- 0.05 M
 - 0.1 M
 - 0.2 M
 - 0.4 M
18. Organic chemistry is the study of compounds mainly containing:
- Carbon
 - Hydrogen
 - Oxygen
 - Nitrogen
19. The general formula of alkanes is:
- C_nH_{2n}
 - C_nH_{2n+2}
 - C_nH_{2n-2}
 - $C_nH_{2n+1}OH$
20. The reaction of an alkene with hydrogen in presence of Ni catalyst is called:
- Oxidation
 - Hydrogenation
 - Substitution
 - Elimination
21. Resonance occurs when:
- Electrons are localized
 - Atoms move within the molecule
 - Electrons are delocalized over two or more structures
 - The molecule is polar

22. Alcohols contain which functional group?
- A. -COOH
 - B. -OH
 - C. -CHO
 - D. -CO-
23. Aldehydes contain which functional group?
- A. -CO-
 - B. -COOH
 - C. -CHO
 - D. -OH
24. Ketones differ from aldehydes because the carbonyl group in ketones is:
- A. At the end of the chain
 - B. Attached to two carbon atoms
 - C. Attached to one carbon and one hydrogen
 - D. Missing oxygen
25. Carboxylic acids have which functional group?
- A. -COOH
 - B. -OH
 - C. -CO-
 - D. -CHO
26. Which of the following is a derivative of carboxylic acid?
- A. Alcohol
 - B. Amide
 - C. Alkane
 - D. Ether
27. Structural isomers have:
- A. Same molecular formula but different structure
 - B. Different molecular formula but same structure
 - C. Same boiling point
 - D. Identical bonding pattern
28. Geometrical isomerism occurs due to:
- A. Free rotation around single bonds
 - B. Restricted rotation around double bonds
 - C. Presence of a triple bond
 - D. Ionic bonding

29. The *cis* isomer of 2-butene has:
- A. Two methyl groups on opposite sides
 - B. Two methyl groups on the same side
 - C. No double bond
 - D. A ring structure
30. Which compound will show geometrical isomerism?
- A. CH_3CH_3
 - B. $\text{CH}_2=\text{CH}_2$
 - C. $\text{CH}_3\text{CH}=\text{CHCH}_3$
 - D. CH_4

SECTION B

SHORT ANSWER QUESTIONS

50 MARKS

Answer ALL QUESTIONS in this section. Ensure that all mechanisms, diagrams, reactions and calculations are neatly shown in your answer booklet. Each question is worth 10 marks.

Question 1

[10 Marks]

- a) Define exothermic and endothermic reactions and give an example of each. (2 marks)
- b) The combustion of methane releases 890 kJ/mol. Write the thermochemical equation and state the sign of ΔH . (2 marks)
- c) State Hess's Law. (2 marks)
- d) Given the data below, calculate enthalpy change (ΔH) for: (2 marks)
- $$\text{C} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g})$$

Reaction	ΔH (kJ mol ⁻¹)
$\text{C} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	-393.5
$\text{CO}(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	-283.0

- e) Briefly explain why Hess's Law is useful in thermochemical calculations. (2 marks)

Question 2

[10 Marks]

- a) (i) Using the information in the table below, construct a Born-Haber cycle for MgCl_2 . (3 marks)

kJ	
atomization enthalpy of Mg	+148
atomization enthalpy of Cl	+122
1st IE of Mg	+738
2nd IE of Mg	+1451
electron affinity of Cl	-349
lattice enthalpy	-2526
calculated ΔH_f	X

- (ii) Calculate the value for X. (2 marks)
- b) (i) Define bond dissociation energy. (1 mark)
- (ii) Using average bond energies, estimate the enthalpy change (ΔH) for: $\text{H}_2 + \text{Cl}_2 \rightarrow 2 \text{HCl}$
 Given: (H-H) = 436 kJ/mol, (Cl-Cl) = 243 kJ/mol, (H-Cl) = 431 kJ/mol. (2 marks)
- (iii) Explain one limitation of using average bond energies to calculate enthalpy changes. (1 mark)

- c) Explain why the lattice energy of MgO is higher than that of NaCl. (1 mark)

Question 3

[10 Marks]

- a) (i) Write the equilibrium expression for:
$$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$$
 (2 marks)
- (ii) State what happens to the position of equilibrium when temperature is increased, assuming the forward reaction is exothermic. (1 mark)
- (iii) Calculate the value of K_c if $[\text{N}_2] = 0.25 \text{ M}$, $[\text{H}_2] = 0.75 \text{ M}$, and $[\text{NH}_3] = 0.50 \text{ M}$ at equilibrium. (2 marks)
- (iv) Explain the role of a catalyst in equilibrium reactions. (1 mark)
- b) (i) Write the dissociation equation and K_{sp} expression for $\text{CaF}_2(\text{s})$. (1 mark)
- (ii) If the solubility of CaF_2 is $2.1 \times 10^{-4} \text{ mol/L}$, calculate its K_{sp} value. (2 marks)
- (iii) Explain the common ion effect using AgCl as an example. (1 mark)

Question 4

[10 Marks]

- a) (i) Sketch a titration curve for a strong acid vs. strong base and label:
(1) start pH, (2) equivalence point, (3) end point region. (3 marks)
- (ii) Explain why the equivalence point of an acid–base titration occurs at pH 7. (1 mark)
- (iii) Suggest a suitable indicator for this (ii) titration and justify your choice. (1 mark)
- b) (i) Write the molecular formula (show working) of hexane and draw its structural formula. (2 marks)
- (ii) Describe the main difference between saturated and unsaturated hydrocarbons. (1 mark)
- c) Draw the resonance structures of benzene and explain why resonance gives it extra stability. (2 marks)

Question 5

[10 Marks]

- a) (i) Write the general formula of propanol and label the functional group. (2 marks)
- (ii) Describe a simple oxidation test and the observations that can distinguish between a primary and a secondary alcohol. (2 marks)

- b) Explain briefly the observations noted when testing aldehydes and ketones using Tollens' reagent. (1 mark)
- c) Write the chemical equation for oxidation of ethanol to ethanoic acid. (1 mark)
- d) State two derivatives of carboxylic acids and one use of each. (2 marks)
- e) Draw and label cis- and trans-2-butene. (2 marks)

SECTION C

LONG ANSWER QUESTION

20 MARKS

Answer ALL QUESTIONS in this section. Ensure that all mechanisms, diagrams, reactions and calculations are neatly shown in your answer booklet. Each question is worth 10 marks.

Question 1

[10 Marks]

A student carried out an experiment to distinguish between saturated and unsaturated hydrocarbons and also measured the rate of KMnO_4 decolourisation and obtained the following average results after repeating the experiment three times. Using the table, to answer the questions where it is relevant.

Sample	Observation with 0.010 M KMnO_4	Time to Change (Average of 3 replicates)	Conclusion
Hexane	No visible change, purple persists	no change	Alkane (saturated)
1-hexene	Purple fades quickly, brown precipitate forms	15 s	Alkene (unsaturated)
Unknown	no change	no change	X

- a) What is the difference between a saturated and an unsaturated hydrocarbon? Give one example of each. (2 marks)
- b) Write the general reaction showing how KMnO_4 reacts with a $\text{C}=\text{C}$ double bond. (2 marks)
- c) Explain why KMnO_4 loses its purple colour when it reacts with an alkene. (1 mark)
- d) If you doubled the concentration of KMnO_4 , would the time to decolourisation be shorter, longer, or the same? Explain. (2 marks)
- e) Why is it important to run duplicate trials in a kinetics experiment? Give two reasons. (2 marks)
- f) Identify X as either alkane or alkene and state your reason. (1 mark)

Question 2**[10 Marks]**

A student carried out some qualitative solubility tests and obtained the following results. Refer to the table to answer the questions that follow.

Mix	Observations	Soluble/Insoluble
$\text{AgNO}_3 + \text{NaCl}$	Milky white appearance Formation of bubbles Formation of white precipitate	Insoluble
$\text{BaCl}_2 + \text{Na}_2\text{SO}_4$	Tiny bubbles Milky white	Insoluble
$\text{CaCl}_2 + \text{Na}_2\text{CO}_3$	Cloudy white colour	Soluble
$\text{NaCl} + \text{Na}_2\text{SO}_4$	No colour change	Soluble

- a) Write the balanced equation of the reaction between: (2 marks)
- (i) $\text{AgNO}_3 + \text{NaCl} \rightarrow ?$ Label any precipitate formed.
- (ii) $\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow ?$ Label any precipitate formed.
- b) Why do some salts form precipitates? (1 mark)

The student also performed a quantitative test to determine the K_{sp} for $\text{Ca}(\text{OH})_2$ by titrating it with 0.10 M HCl and had the following results:

Volume $\text{Ca}(\text{OH})_2$ (mL)	HCl (M)	Volume HCl (mL)
50.00	0.1000	153.1

- c) Write a balanced equation for the reaction between $\text{Ca}(\text{OH})_2$ and HCl. (2 marks)
- d) Calculate the moles (n) of HCl used. (1 mark)
- e) Calculate the moles (n) of $\text{Ca}(\text{OH})_2$. (1 mark)
- f) Calculate the solubility (s) of $\text{Ca}(\text{OH})_2$. (1 mark)
- g) Write the K_{sp} expression and calculate the value of K_{sp} . (2 marks)

PERIODIC TABLE OF ELEMENTS

1	H	Hydrogen	2	He	Helium
3	Li	Lithium	4	Be	Beryllium
11	Na	Sodium	12	Mg	Magnesium
19	K	Potassium	20	Ca	Calcium
37	Rb	Rubidium	38	Sr	Strontium
55	Cs	Cesium	56	Ba	Barium
87	Fr	Francium	88	Ra	Radium
21	Sc	Scandium	22	Ti	Titanium
39	Y	Yttrium	40	Zr	Zirconium
57	La	Lanthanum	58	Ce	Cerium
71	Lu	Lutetium	72	Hf	Hafnium
89	Ac	Actinium	90	Th	Thorium
101	Db	Dubnium	102	Ni	Nickel
103	Lr	Lutetium	104	Rf	Rutherfordium
105	Db	Dubnium	106	Sg	S seaborgium
107	Bh	Berkelium	108	Hs	Hassium
109	Mt	Moscovium	110	Ds	Darmstadtium
111	Rg	Roganium	112	Cn	Copernicium
113	Nh	Nihonium	114	Fl	Flerovium
115	Mc	Mendelevium	116	Lv	Livermorium
117	Ts	Tennessium	118	Og	Oganesson
81	Tl	Thallium	82	Pb	Lead
83	Bi	Bismuth	84	Po	Polonium
85	At	Astatine	86	Rn	Radon
51	Sb	Antimony	52	Te	Tellurium
53	I	Iodine	54	Xe	Xenon
49	In	Indium	50	Sn	Stannum
48	Cd	Cadmium	47	Ag	Silver
46	Pd	Palladium	45	Rh	Rhodium
44	Ru	Ruthenium	43	Tc	Technetium
42	Mo	Molybdenum	41	Nb	Niobium
40	Zr	Zirconium	39	Y	Yttrium
38	Sr	Strontium	37	Rb	Rubidium
36	Kr	Krypton	35	Br	Bromine
34	Se	Selenium	33	As	Arsenic
32	Ge	Germanium	31	Ga	Gallium
30	Zn	Zinc	29	Cu	Copper
28	Ni	Nickel	27	Co	Cobalt
26	Fe	Iron	25	Mn	Manganese
24	Cr	Chromium	23	V	Vanadium
22	Ti	Titanium	21	Sc	Scandium
20	Ca	Calcium	19	K	Potassium
18	Ar	Argon	17	Cl	Chlorine
16	S	Sulfur	15	P	Phosphorus
14	Si	Silicon	13	Al	Aluminum
12	Mg	Magnesium	11	Na	Sodium
10	Ne	Neon	9	F	Fluorine
8	O	Oxygen	7	N	Nitrogen
6	C	Carbon	5	B	Boron
4	Be	Beryllium	3	Li	Lithium
2	He	Helium	1	H	Hydrogen

58	Ce	Cerium	59	Pr	Praseodymium	60	Nd	Neodymium	61	Pm	Promethium	62	Sm	Samarium	63	Eu	Europium	64	Gd	Gadolinium	65	Tb	Terbium	66	Dy	Dysprosium	67	Ho	Holmium	68	Er	Erbium	69	Tm	Thulium	70	Yb	Ytterbium	71	Lu	Lutetium
90	Th	Thorium	91	Pa	Protactinium	92	U	Uranium	93	Np	Neptunium	94	Pu	Plutonium	95	Am	Americium	96	Cm	Curium	97	Bk	Berkelium	98	Cf	Californium	99	Es	Einsteinium	100	Fm	Fermium	101	Md	Mendelevium	102	No	Nobelium	103	Lr	Lutetium

THE END

