UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIOENGINEERING TECHNOLOGY

FINAL EXAMINATION

OCTOBER 2025 SEMESTER

COURSE CODE	:	CCB10303
COURSE NAME	:	PHYSICAL CHEMISTRY
PROGRAMME NAME	:	BACHELOR OF CHEMICAL ENGINEERING WITH HONOURS
DATE	:	2 FEBRUARY 2026
TIME	:	2.00 PM – 5.00 PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consists of FIVE (5) questions. Answer ALL questions.
4. Please write your answers on the answer booklet provided.
5. Answer all questions in English language ONLY.

(Total: 100 marks)

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

Question 1

(a) There are **THREE (3)** postulates of Kinetic Theory of a perfect gas. Describe all of them.

(6 marks)

(b) Suppose that 10.0 moles of ethane gas, C_2H_6 is confined to 4.860 dm^3 at 27°C. Calculate the pressure exerted by the ethane using:

i. the perfect gas equation and

(3 marks)

ii. the van der Waals equation. Given that for the ethane, a = 5.507 atm dm^6 mol^{-2} and b = 6.51 x 10^{-2} dm^3 mol^{-1}.

(4 marks)

(c) A gas obeys the van der Waals equation with a = 0.580 m^6 Pa mol^{-2}. Its volume is found to be 3.50 × 10^{-4} m^3 mol^{-1} at 273 K and 5.0 MPa. Calculate the van der Waals constant b. Then, determine the compression factor for this gas at the same temperature and pressure.

(7 marks)

Question 2

(a) Distinguish between the First Law of Thermodynamics and Second Law of Thermodynamics.

(3 marks)

(b) A sample consisting of 2.00 moles of perfect gas molecules, for which $C_{v,m}$ = 2.5R, initially at P = 111 kPa and T= 277 K, is heated reversibly to 356 K at constant volume. Calculate the final pressure, ΔU, q, and w.

(10 marks)

(c) Calculate the final temperature of a 16.0 g sample of carbon dioxide that is expanded reversibly and adiabatically from 500 cm^3 at 298.15 K to 2.00 dm^3. Given that the $C_{p,m}$ = 37.11 J/K.mol.

(7 marks)

Question 3

(a) Calculate the enthalpy for the reaction of ethylene with fluorine based on the following enthalpies of reaction.

$$\mathbf{C_2H_4\,(g) + 6F_2\,(g) \rightarrow 2CF_4\,(g) + 4HF\,(g)}$$

Given:

$H_2\,(g) + F_2\,(g) \rightarrow 2HF\,(g)$ $\quad \Delta H = -537$ kJ

$C\,(S) + 2F_2\,(g) \rightarrow CF_4\,(g)$ $\quad \Delta H = -680$ kJ

$2C\,(s) + 2H_2\,(g) \rightarrow C_2H_4\,(g)$ $\quad \Delta H = 52.3$ kJ

(6 marks)

(b) In an experiment, 2.95 g of glucose was completely burned in oxygen. The heat produced was found to raise the temperature of 15.0 dm^3 of water by 13.7°C. Calculate the enthalpy changes of combustion of glucose. Given that molecular weight of glucose = 180 g/mol and specific heat of water = 4.184 J/g.°C.

(8 marks)

(c) Relate work and heat in chemistry and Identify the sign conventions for work and heat.

(6 marks)

Question 4

(a) Define the following terms:

i. Isochoric process

ii. Isobaric process

(4 marks)

(b) The Gibbs energy is commonly used in chemistry. By the assumption that ΔH and ΔS of the reaction are constant with temperature, predict how ΔG will change with the decrease of temperature.

(3 marks)

(c) A Carnot Cycle is the most efficient heat engine where it fully converts heat energy from a heat source into work. With the aid of a diagram, discuss the process involved in the Carnot Cycle.

(8 marks)

(d) The values of ΔH and ΔS for a chemical reaction are – 65.8 kJ mol^{-1} and –189.2 J K^{-1} mol^{-1}, respectively and the values can be taken to be independent of temperature. Determine the temperature when ΔG is zero.

(5 marks)

Question 5

(a) The reaction between A and B is first order to A and second order to B.

i. Determine the rate law for this reaction

(2 marks)

ii. Determine the unit of k in minute.

(3 marks)

(b) Given a set of values of reactant concentration versus time, outline how you would determine whether the reaction exhibited first order kinetics.

(6 marks)

(c) Using data shown in **Table 1**, prove that the decomposition of N_2O follows the first order kinetics.

Table 1: The concentration of N_2O vs time

10^3 [N_2O] (mol.dm^{-3})	100	61	37	10
Time (s)	0	50	100	230

(9 marks)

END OF EXAMINATION PAPER

APPENDIX A

PERIODIC TABLE

1 H 1.00794																	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.581538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 196.56655	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.94.79	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

APPENDIX B

Conversion Factor

Mass
1 lb_m = 0.453592 kg
1 ton = 2000 lb_m
1 kg = 2.20462 lb_m

Force
1 lb_f = 4.448222 N
1N = 0.224809 lb_f = 1 kg.m/s^2

Volume
1 ft^3 = 0.028317 m^3
1 L = 0.001 m^3
1 m^3 = 35.32 ft^3
1 cm^3 = 0.06102 in^3
1 gal =0.0037854 m^3
1 gal/min = 6.31 x 10^{-5} m^3/s

Density
1kg /m^3 = 0.062428 lbm/ ft^3

Pressure
1 pascal (Pa) = 1 N/m^2 = 10^{-5} bar
1 atm = 760 mmHg = 760 torr
1 atm = 101.325 kPa = 1.01325 bar

Constants

Faraday Constant = 96 485 Coulombs mol^{-1}
Gas Constant = 0.082 L atm K^{-1} mol^{-1}
= 8.314 L kPa K^{-1} mol^{-1}
= 8.314 m^3 Pa K^{-1} mol^{-1}
= 8.314 J mol^{-1} K^{-1}
Specific heat (water) = 4.184 J g^{-1} $°C^{-1}$

Equations

$$E = E^0 - \frac{RT}{vF}\ln Q$$, Where: F = 96,485 C mol^{-1}

$$K_p = K_c(RT)^{\Delta n}$$

$$q = mS\Delta T$$

$$W = -nRT\ln\frac{V_2}{V_1}$$

$$W = -P\Delta V$$

$$q = C\Delta T$$

$$\Delta U = nC_V\Delta T$$

$$\Delta H = nC_p\Delta T$$

$$C_{p,M} - C_{V,M} = R$$

$$\frac{C_{p,M}}{C_{V,M}} = \gamma$$

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$$

$Z = PV_M/RT$

$(P + an^2/V^2)\ (V - nb) = nRT$

$$\left(P + \frac{a}{V_M^2}\right)(V_M - b) = RT$$

$$T_f = T_i\left(\frac{V_i}{V_f}\right)^{1/c}$$

$$c = C_{V,m} / R$$

$$V_i T_i^c = V_f T_f^c$$

$\Delta_r H^\circ\ (T_2) = \Delta_r H^\circ\ (T_1) + (T_2 - T_1)\ \Delta_r C_p^\circ$

$$\Delta S = \frac{\Delta q}{\Delta T}$$

$$K_P^0 = e^{-\Delta G^0\ /RT}$$

$$\Delta G^\circ = -RT \ln K_p^\circ$$

$$\ln \frac{K_P^0(T_2)}{K_P^0(T_1)} \approx \frac{\Delta H^0}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$