TUNKU ABDUL RAHMAN UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

CENTRE FOR PRE-UNIVERSITY STUDIES

ACADEMIC YEAR 2022/2023

MAY EXAMINATION

FPCH1024 PHYSICAL AND INORGANIC CHEMISTRY

MONDAY, 15 MAY 2023 TIME: 2.00 PM – 4.00 PM (2 HOURS)

FOUNDATION IN SCIENCE

Instructions to Candidates:

1. This question paper consists of **FIVE** questions.
2. Answer **ALL** questions in the answer booklet(s) provided and follow all the instructions stated on the answer booklet(s).
3. Write in dark blue or black pen.
4. The Periodic Table of the element is provided in page 6.
5. The standard electrode potential and redox potentials are provided in page 7 and 8.

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Answer **ALL** questions.

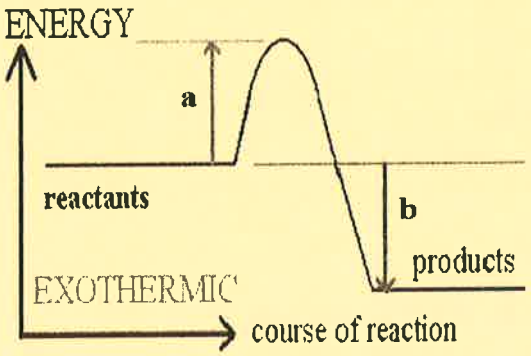
Question 1

a) Define the following terms:

(i) Half-life (1 mark)

(ii) Dynamic equilibrium (2 marks)

b) Diagram below shows an uncatalysed exothermic reaction.



(i) Label **a** and **b**. (2 marks)

(ii) Draw an energy level diagram on your answer booklet to show the activation energy of catalysed reaction, and label it as $E_{a(catalysed)}$. (2 marks)

c) The numerical value of the solubility product, K_{sp}, for lead(II) fluoride is 3.3×10^{-8}.

(i) Write an expression for the solubility product, K_{sp}, of PbF_2. (1 mark)

(ii) Calculate the concentration of PbF_2 in a saturated solution by using the numerical value of K_{sp} given. (2 marks)

(iii) State whether $PbCl_2$ is more soluble or less soluble compared to PbF_2 with your reasoning. [$K_{sp}(PbCl_2) = 1.7 \times 10^{-5} mol^3\ dm^{-9}$] (2 marks)

d) Partition coefficient of a substance X between ether and water is 8.0.

(i) Calculate the mass of X that will be extracted when 100 cm^3 of an aqueous solution containing 5 g of X is shaken with 100 cm^3 of ether. (2 marks)

(ii) Calculate the mass of X that will be extracted when 100 cm^3 of an aqueous solution containing 5 g of X is shaken with two separate 50 cm^3 portions of ether. Give your final answer in **one** decimal place. (4 marks)

(iii) State whether method in d)(ii) is more or less efficient than method in d)(i). (1 mark)

(iv) Give one reason that ether is used as solvent for solvent extraction. (1 mark)

[Total: 20 marks]

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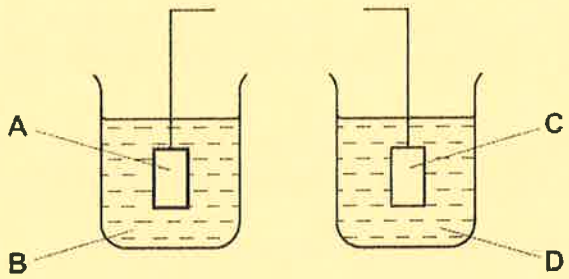
Question 2

a) Define the term *standard electrode potential.* (3 marks)

b) The following incomplete diagram shows the apparatus that can be used to measure the E^{θ}_{cell} for a cell composed of the Fe^{3+}/Fe^{2+} and Ag^{+}/Ag half-cells.



(i) Complete the diagram, labelling the components you add. (2 marks)

(ii) Name the components **A - D**. (4 marks)

(iii) Label the positive and negative terminals on the diagram. (2 marks)

(iv) Indicate the direction of flow of electrons whether it is from **left to right** or **right to left** in the external circuit. (1 mark)

(v) Write the equations for the reactions at the negative and positive terminals. (2 marks)

(vi) Construct an overall equation of the above reactions, including state symbols. (2 marks)

c) Calculate E^{θ}_{cell}, and predict whether the following reactions are **feasible or not feasible** under standard conditions.

(i) $2Cl^{-}(aq) + I_2(aq) \rightarrow Cl_2(aq) + 2I^{-}(aq)$ (2 marks)

(ii) $Ni(s) + Sn^{4+}(aq) \rightarrow Ni^{2+}(aq) + Sn^{2+}(aq)$ (2 marks)

[Total: 20 marks]

Question 3

a) Calculate the equilibrium constant, K_c. and give your final answer in **three** significant figures for the following reactions:

(i) $2Ag^{+}(aq) + Fe(s) \rightleftharpoons 2Ag(s) + Fe^{2+}(aq)$ (3 marks)

(ii) $Cu^{2+}(aq) + Zn(s) \rightleftharpoons Cu^{2+}(aq) + Zn^{2+}(aq)$ (3 marks)

b) Dry cell is a practical battery that is used in a small electrical appliance.

(i) Give two advantages of dry cell. (2 marks)

(ii) Give two disadvantages of dry cell. (2 marks)

Question 3 (Continued)

c) Complete the following table.

Solution	Products of electrolysis	
	Anode	Cathode
NaCl (molten)		
NaCl (aqueous)		
NaCl (concentrated)		

(6 marks)

d) Dilute sulfuric acid is electrolysed for 50.0 minutes with a current of 1.20A. A different gas is collected at each electrode. The volume of two gases is measured under room conditions.

(i) Calculate the electric charge of the above electrolytic process. (1 mark)

(ii) Calculate the volume of hydrogen gas, in cm^3, that could be collected at the cathode. Give your answer in **three** significant figures. (1 mol of any gas occupied 24 000 cm^3 at room condition) (3 marks)

[Total: 20 marks]

Question 4

a) Write the full electronic configuration of the following atoms.

(i) Mg (1 mark)

(ii) Cl (1 mark)

(iii) Fe (1 mark)

(iv) Cu (1 mark)

b) Write the balanced equation for the following reactions:

(i) calcium with hot water, including state symbols. (2 marks)

(ii) calcium with hydrochloric acid, including state symbols. (2 marks)

(iii) decomposition of calcium nitrate, including state symbols. (2 marks)

(iv) decomposition of calcium carbonate, including state symbols. (2 marks)

c) (i) Describe the melting point of the Group 2 element varies down the group. (1 mark)

(ii) Explain your answer in c)(i), in terms of bonding. (3 marks)

d) (i) Describe the oxidising power of Group 17 elements down the group. (1 mark)

(ii) Explain your answer in d)(i). (3 marks)

[Total: 20 marks]

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Question 5

a) F_2, Cl_2, Br_2 and I_2 are diatomic molecule. They are all halogen molecules.

(i) State the bonding and structure of the above halogen molecules. (2 marks)

(ii) State the trend of the volatility of halogens down the group. (1 mark)

(iii) Explain your answer in a)(ii). (3 marks)

b) Silver nitrate, $AgNO_3(aq)$, and ammonia solution, $NH_3(aq)$, are solutions commonly used to identify the presence of halide ions.

(i) Give the observation when silver nitrate is added to sodium chloride, $NaCl(aq)$. (2 marks)

(ii) Write the ionic equation for the reaction of b)(i). (1 mark)

(iii) State the observation when ammonia solution is added. (1 mark)

c) (i) Define '*transition element*'. (2 marks)

(ii) Suggest a reason why zinc is not a transition element. (1 mark)

d) Determine the oxidation number of the following underlined element:

(i) $[\underline{Cu}Cl_4]^{2-}$ (1 mark)

(ii) $[\underline{Co}(NH_3)]^{3+}$ (1 mark)

(iii) $\underline{Ti}O$ (1 mark)

e) Most of the transition metal complexes are coloured. Electrons in the lower energy group absorb radiation in the visible region of electromagnetic spectrum and are promoted to the higher energy level. The colour not absorbed will be seen as the colour of the complexes.

(i) Explain why Cu(I) complexes are colourless. (2 marks)

(ii) Predict the colour of solution when $CuSO_4(s)$ dissolved in water. (1 mark)

(iii) List one factor that can affect the colour of complexes. (1 mark)

[Total: 20 marks]

10 The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0		Key atomic number atomic symbol name relative atomic mass									5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	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 lawrencium –

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Standard electrode potential and redox potentials, $E^{\ominus}$ at 298 K (25°C)

Electrode reaction	$E^{\ominus}$/V
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Al^{3+} + 3e^- \rightleftharpoons Al$	–1.66
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	–2.90
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	–2.87
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$2HOCl + 2H^+ + 2e^- \rightleftharpoons Cl_2 + 2H_2O$	+1.64
$ClO^- + H_2O + 2e^- \rightleftharpoons Cl^- + 2OH^-$	+0.89
$Co^{2+} + 2e^- \rightleftharpoons Co$	–0.28
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+1.82
$[Co(NH_3)_6]^{2+} + 2e^- \rightleftharpoons Co + 6NH_3$	–0.43
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	–0.91
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	–0.74
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	–0.41
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$Cu^+ + e^- \rightleftharpoons Cu$	+0.52
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+0.15
$[Cu(NH_3)_4]^{2+} + 2e^- \rightleftharpoons Cu + 4NH_3$	–0.05
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	–0.44
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	–0.04
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$[Fe(CN)_6]^{3-} + e^- \rightleftharpoons [Fe(CN)_6]^{4-}$	+0.36
$Fe(OH)_3 + e^- \rightleftharpoons Fe(OH)_2 + OH^-$	–0.56
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	–0.83
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$K^+ + e^- \rightleftharpoons K$	–2.92
$Li^+ + e^- \rightleftharpoons Li$	–3.04
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	–2.38
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	–1.18
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.49
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
$MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$	+0.56
$MnO_4^- + 4H^+ + 3e^- \rightleftharpoons MnO_2 + 2H_2O$	+1.67
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$NO_3^- + 3H^+ + 2e^- \rightleftharpoons HNO_2 + H_2O$	+0.94
$NO_3^- + 10H^+ + 8e^- \rightleftharpoons NH_4^+ + 3H_2O$	+0.87

Electrode reaction	$E^{\ominus}$/V
$Na^+ + e^- \rightleftharpoons Na$	−2.71
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	−0.25
$[Ni(NH_3)_6]^{2+} + 2e^- \rightleftharpoons Ni + 6NH_3$	−0.51
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$HO_2^- + H_2O + 2e^- \rightleftharpoons 3OH^-$	+0.88
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+0.68
$O_2 + H_2O + 2e^- \rightleftharpoons HO_2^- + OH^-$	−0.08
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	−0.13
$Pb^{4+} + 2e^- \rightleftharpoons Pb^{2+}$	+1.69
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	−0.14
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$V^{2+} + 2e^- \rightleftharpoons V$	−1.20
$V^{3+} + e^- \rightleftharpoons V^{2+}$	−0.26
$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
$VO_2^+ + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$	+1.00
$VO_3^- + 4H^+ + e^- \rightleftharpoons VO^{2+} + 2H_2O$	+1.00
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	−0.76

All ionic states refer to aqueous ions but other state symbols have been omitted.