Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	PHYSICAL CHEMISTRY
COURSE CODE	:	DAS 12303
PROGRAMME	:	DAU
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN SECTION A AND **ONE (1)** QUESTION IN SECTION B.

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

SECTION A

Q1 (a) Define the term physical property.

(1 mark)

(b) Based on **Figure Q1(b)**, differentiate between the physical and chemical properties of a matter.

(8 marks)

(c) Indicate the number of protons, neutrons electrons and charge of ions in **Figure Q1(c)**. Reconstruct the table in your answer sheet.

(5 marks)

(d) Methane, a flammable gas is used industrially to produce electricity via combustion process which releases 890.4 kJ of heat.

(i) Write the thermochemical equation for the process.

(2 marks)

(ii) Calculate the amount of heat release when 200 g of methane is completely combusted.
(Given C = 12 $g \cdot mol^{-1}$; H = 1 $g \cdot mol^{-1}$).

(4 marks)

Q2 (a) State the pricnciple of Charle's and Boyle's law.

(2 marks)

(b) A vessel with the volume of 21.1 cm^3 contains a mixture of methane and oxygen gas. At 21 °C, the partial pressure of methane and oxygen gas are 0.211 atm and 0.22 atm, respectively. Compute the mass of each gasses in the mixture.

(10 marks)

(c) A 24 g of potassium hydroxide is dissolved in 210 mL of distilled water. (Given K = 39 $g \cdot mol^{-1}$; O = 16 $gmol^{-1}$; H = 1 $g \cdot mol^{-1}$)
Compute the:

(i) Molality of the solution.

(2 marks)

(ii) Molarity of the solution.

(2 marks)

(iii) $(\% \frac{w}{v})$ of the solution.

(2 marks)

(iv) Volume of the solution required to prepare 2 L of 1 M of KOH.

(2 marks)

Q3 (a) At 80 °C, a 5000 mL flask contains 2.6 M FeO, 2.0 M CO, 3.0 M Fe and 0.75 M CO_2. The equation for the reaction is:

$$FeO\ (s) + CO\ (g) \rightleftharpoons Fe\ (s) + CO_2\ (g) \qquad \textit{Equation 1}$$

(i) Identify whether the equilibrium in *Equation 1* is homogeneous or heterogeneous.

(1 mark)

(ii) Find the K_c for both forward and reverse reactions of *Equation 1*.

(4 marks)

(iii) Calculate K_p for both forward and reverse reaction of *Equation 1*.
(If the partial pressures are: FeO = 1.2 atm; CO = 1.0 atm; Fe =1.5 atm; and CO_2 = 1.3 atm).

(4 marks)

(iv) Calculate the K_c for the given reaction in *Equation 1* if the value of K_p at 270 °C is 2.6×10^{-4}.

(3 marks)

(v) If the reaction in *Equation 1* is reduced to half, find K_c for the forward reaction.

(2 marks)

(b) The formation of iodine molecules I_2 from its atom I is as follows.

$$I\ (g) + I\ (g) \rightarrow I_2\ (g) \qquad \textit{Equation 2}$$

(i) Write the rate expressions for the reactions in *Equation 2* in terms of the dissappearance of the reactants and the appearance of products.

(2 marks)

(ii) If the initial concentration of $[I]_0$ = 0.086 M, calculate the concentration after 2 minutes.

(2 marks)

(iii) Calculate the half-life if $[I]_0$ = 0.6 M.

(2 marks)

Q4 (a) Define the acid-base according to the theory of Arrhenius and Bronsted-Lowry.

(2 marks)

(b) The hydroxide ion (OH^-) concentration for sodium hydroxide is 5.1×10^{-9} M.
(Given Na = 23 $g \cdot mol^{-1}$; O = 16 $g \cdot mol^{-1}$; H = 1 $g \cdot mol^{-1}$)
Determine:

(i) The pH of the sodium hydroxide.

(2 marks)

(ii) The concentration of hydrogen ion.

(2 marks)

(iii) The mass of sodium hydroxide needed to prepare 546 mL of the solution with pH 10.

(6 marks)

(c) An electrochemical reaction is described by the following equation.
(Given: $[Co^{2+}] = 0.15$ M; $[Fe]^{2+} = 0.68$ M)

$$Co\ (s) + Fe^{2+}\ (aq) \rightarrow Co^{2+}\ (aq) + Fe\ (s) \qquad \textit{Equation 3}$$

(i) Write the half cell reactions for *Equation 3*.

(2 marks)

(ii) Calculate the sum of standard cell potential for the electrochemical cell.

(2 marks)

(iii) Identify whether the reaction is spontaneous or non-spontaneous.

(1 mark)

(iv) Assume the process in *Equation 3* is a spontaneuos reaction, calculate the cell potential (E_{cell}) for the reaction.

(3 marks)

SECTION B

Q5 The atomic number of Silicone, (Si) is 14 and Oxygen, (O) is 8.

(a) Determine the formal charge for each atom of SiO_2.

(4 marks)

(b) Draw the Lewis dot symbol to show the formation of silicon dioxide, SiO_2.

(4 marks)

(c) Classify the compounds in **Figure Q5(c)** based on the type of chemical bonds whether it is ionic or covalent.

(6 marks)

(d) Based on **Figure Q5(c),** identify **two (2)** compounds that are polar.

(2 marks)

Q6 The atomic number of magnesium, (Mg) is 12.

(a) Determine the four quantum numbers of Mg^{2+} ion.

(5 marks)

(b) Draw the orbital diagram for all electrons in Mg^{2+} ion according to Hund's rule and identify the magnetic property of the ion.

(3 marks)

(c) Write the electron configuration for Mg^{2+} ion according to Aufbau principle.

(2 marks)

(d) Based on **Figure Q6(d),** identify the species which are isoelectronic.

(2 marks)

(e) The following sets of quantum numbers are incorrect. Identify the incorrect quantum number and explain the reason it is incorrect.

(i) $(2, 1, 2, +½)$

(3 marks)

(ii) $(1, 0, 0, 1)$

(3 marks)

(f) Based on **Figure Q6(f)**, two electrons in the same atom have the following set of quantum numbers. Identify the subshell for these electrons.

(2 marks)

END OF QUESTIONS

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• Toxicity	• Acidity
• Flammability	• Melting point
• Colour	• Conductivity
• Density	• Reactivity

Figure Q1(b)

Symbol	$^{56}_{26}Fe^{3+}$	$^{80}_{35}Br^{-}$
Proton	26	
Neutron		
Electron		36
Charge		1-

Figure Q1(c)

CH_4	NaCl	LiF	H_2O	CO_2	Al_2O_3

Figure Q5(c)

(i) Cl^- (ii) Ar (iii) Mn^{2+} (iv) Zn^{3+}

Figure Q6(d)

Electron A : (3, 1, 0, +½)
Electron B : (3, 1,-1, +½)

Figure Q6(f)

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FORMULA

1. $n = \frac{MV}{1000}$
2. $M_1V_1 = M_2V_2$
3. $\frac{M_aV_a}{a} = \frac{M_bV_b}{b}$
4. $pH = - \log [H^+]$
5. $pH + pOH = 14$
6. $P_1V_1 = P_2V_2$
7. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
8. $PV=nRT$
9. $E° = E°_{SRP} + E°_{SOP}$
10. $\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$
11. $\ln \frac{[A]t}{[A]0} = kt$

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STANDARD REDUCTION POTENTIAL

Half-Reaction	$E°$(V)
$F_2(g) + 2e^- \longrightarrow 2F^-(aq)$	+2.87
$O_3(g) + 2H^+(aq) + 2e^- \longrightarrow O_2(g) + H_2O$	+2.07
$Co^{3+}(aq) + e^- \longrightarrow Co^{2+}(aq)$	+1.82
$H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O$	+1.77
$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \longrightarrow PbSO_4(s) + 2H_2O$	+1.70
$Ce^{4+}(aq) + e^- \longrightarrow Ce^{3+}(aq)$	+1.61
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O$	+1.51
$Au^{3+}(aq) + 3e^- \longrightarrow Au(s)$	+1.50
$Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$	+1.36
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O$	+1.33
$MnO_2(s) + 4H^+(aq) + 2e^- \longrightarrow Mn^{2+}(aq) + 2H_2O$	+1.23
$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O$	+1.23
$Br_2(l) + 2e^- \longrightarrow 2Br^-(aq)$	+1.07
$NO_3^-(aq) + 4H^+(aq) + 3e^- \longrightarrow NO(g) + 2H_2O$	+0.96
$2Hg^{2+}(aq) + 2e^- \longrightarrow Hg_2^{2+}(aq)$	+0.92
$Hg_2^{2+}(aq) + 2e^- \longrightarrow 2Hg(l)$	+0.85
$Ag^+(aq) + e^- \longrightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H^+(aq) + 2e^- \longrightarrow H_2O_2(aq)$	+0.68
$MnO_4^-(aq) + 2H_2O + 3e^- \longrightarrow MnO_2(s) + 4OH^-(aq)$	+0.59
$I_2(s) + 2e^- \longrightarrow 2I^-(aq)$	+0.53
$O_2(g) + 2H_2O + 4e^- \longrightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$	+0.34
$AgCl(s) + e^- \longrightarrow Ag(s) + Cl^-(aq)$	+0.22
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \longrightarrow SO_2(g) + 2H_2O$	+0.20
$Cu^{2+}(aq) + e^- \longrightarrow Cu^+(aq)$	+0.15
$Sn^{4+}(aq) + 2e^- \longrightarrow Sn^{2+}(aq)$	+0.13
$2H^+(aq) + 2e^- \longrightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \longrightarrow Pb(s)$	−0.13
$Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$	−0.14
$Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$	−0.25
$Co^{2+}(aq) + 2e^- \longrightarrow Co(s)$	−0.28
$PbSO_4(s) + 2e^- \longrightarrow Pb(s) + SO_4^{2-}(aq)$	−0.31
$Cd^{2+}(aq) + 2e^- \longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$	−0.44
$Cr^{3+}(aq) + 3e^- \longrightarrow Cr(s)$	−0.74
$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$	−0.76
$2H_2O + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$	−0.83
$Mn^{2+}(aq) + 2e^- \longrightarrow Mn(s)$	−1.18
$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$	−1.66
$Be^{2+}(aq) + 2e^- \longrightarrow Be(s)$	−1.85
$Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^- \longrightarrow Na(s)$	−2.71
$Ca^{2+}(aq) + 2e^- \longrightarrow Ca(s)$	−2.87
$Sr^{2+}(aq) + 2e^- \longrightarrow Sr(s)$	−2.89
$Ba^{2+}(aq) + 2e^- \longrightarrow Ba(s)$	−2.90
$K^+(aq) + e^- \longrightarrow K(s)$	−2.93
$Li^+(aq) + e^- \longrightarrow Li(s)$	−3.05

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CONVERSION TABLE

Quantity	Equivalent Values
Mass	1 kg = 1000 g = 0.001 metric ton = 2.20462 lb_m = 35.27392 oz 1 lb_m = 16 oz = 5×10^{-4} ton = 453.593 g = 0.453593 kg
Length	1 m = 100 cm = 1000 mm = 10^6 μm = 10^{10} Å 1 m = 39.37 in = 3.2808 ft = 1.0936 yd = 0.0006214 mile 1 ft = 12 in = 1/3 yd = 0.3048 m = 30.48 cm
Volume	1 m^3 = 1000 liters = 10^6 cm^3 = 10^6 ml 1 m^3 = 35.3145 ft^3 = 220.83 imperial gallons = 264.17 gal = 1056.68 qt 1 ft^3 = 1728 in^3 = 7.4805 gal = 0.028317 m^3 = 28.317 liters = 28317 cm^3
Force	1 N = 1 kg·m/s^2 = 10^5 dynes = 10^5 g·cm/s^2 = 0.22481 lb_f 1 lb_f = 32.174 lb_m·ft/s^2 = 4.4482 N
Pressure	1 atm = 1.01325×10^5 N/m^2 (Pa) = 101.325 kPa = 1.01325 bars 1 atm = 1.01325×10^6 dynes/cm^2 1 atm = 760 mmHg at 0°C (torr) = 10.333 m H_2O at 4°C = 14.696 lb_f/in^2 (psi) 1 atm = 33.9 ft H_20 at 4°C = 29.921 inHg at 0°C
Energy	1 J = 1 N·m = 10^7 ergs = 10^7 dyne·cm = 2.778×10^{-7} kW·h 1 J = 0.23901 cal = 0.7376 ft-lb_f = 9.486×10^{-4} Btu
Power	1 W = 1 J/s = 1.341×10^{-3} hp