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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

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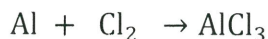
COURSE NAME : PHYSICAL CHEMISTRY
COURSE CODE : DAS 12303
PROGRAMME CODE : DAU
EXAMINATION DATE : DECEMBER 2016 / JANUARY 2017
DURATION : 3 HOURS
INSTRUCTION : ANSWERS **FIVE (5)** QUESTIONS ONLY

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THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

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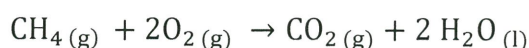
Q1 (a) Aluminum reacts with chlorine gas to form aluminum chloride via the following reaction.



- (i) Write a balanced equation.
- (ii) Calculate the moles of each reactant, given that 34.0 g of aluminium was reacted with 39.0 g of chlorine gas.
- (iii) Determine the limiting reactant.
- (iv) Calculate the amount of excess reactant (in grams) left at the end of reaction.
- (v) Determine the mass of aluminium chloride produced.

(10 marks)

(b) (i) Methane, the principal component of natural gas is used for heating and cooking. The combustion process is as follows.



If 15.0 moles of CH_4 are reacted, determine the volume of CO_2 (in liters) produced at 23.0 °C and 0.985 atm.

(5 marks)

(ii) A gas evolved during fermentation of glucose has a volume of 0.78 L at 20 °C and 1 atm. Calculate the volume of this gas at the fermentation temperature of 36.5 °C and 1 atm pressure.

(5 marks)

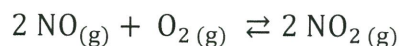
Q2 (a) (i) Determine the volume of solution (in liters) needed to dissolve 25.5 g hydrogen phosphate, H_3PO_4 if a concentration of 0.25 M is prepared.

(5 marks)

(ii) Determine the boiling point elevation (ΔT_b) of a solution containing 255 g of non-electrolyte sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ in 812 g of water ($K_b = 0.520^\circ\text{C}/m$).

(5 marks)

(b) (i) The following equilibrium process has been studied at 230 °C.

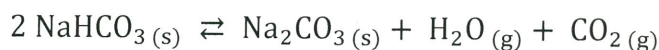


In one experiment, the concentration of the reacting species at equilibrium are found to be $[\text{NO}] = 0.0542\text{ M}$, $[\text{O}_2] = 0.127\text{ M}$ and $[\text{NO}_2] = 15.5\text{ M}$. Calculate the equilibrium constant of the reaction.

(4 marks)

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- (ii) Heating solid sodium bicarbonate in a closed vessel establishes the following equilibrium



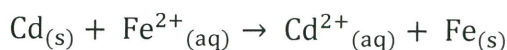
Conclude what will happen to the equilibrium position if some of the CO_2 were removed from the system.

(1 marks)

- (iii) The equilibrium constant (K_c) for the reaction $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ is 4.63×10^{-3} at 25°C . Calculate the value of K_p at this temperature.

(5 marks)

- Q3** (a) A voltaic cell is assembled as follows:



- Write the half cell reactions at the anode and cathode.
- Calculate the standard emf, E°_{cell} of this reaction at 298 K.
- Draw notation cell of the reaction.
- Calculate E_{cell} , given $[\text{Cd}^{2+}] = 0.010 \text{ M}$, and $[\text{Fe}^{2+}] = 0.60 \text{ M}$.

Given:

$$E^\circ \text{Fe}^{2+}/\text{Fe} = -0.44 \text{ V}$$

$$E^\circ \text{Cd}^{2+}/\text{Cd} = -0.40 \text{ V}$$

(10 marks)

- (b) (i) A solution of formic acid (HCOOH) has a pH of 2.53. Determine the mole of formic acid in 100 mL of the solution given that the K_a for formic acid is 1.78×10^{-4} .

(5 marks)

- (ii) Calculate the pOH of $1.98 \times 10^{-3} \text{ mol}$ of 5.50 mL potassium hydroxide solution.

(5 marks)

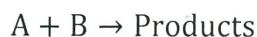
- Q4** (a) Write the reaction rate expression for the following reactions:



(5 marks)

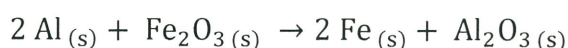
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- (b) The following data were obtained for the chemical reaction:

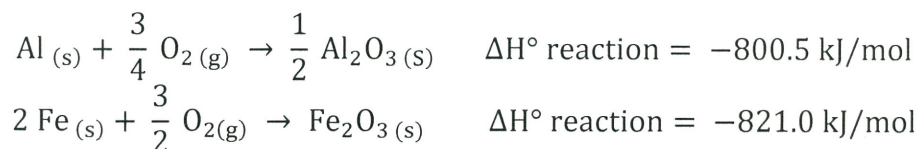


| Experiment no. | Initial A (mol/L) | Initial B (mol/L) | Initial rate of formation of products (M/s) |
|----------------|-------------------|-------------------|---|
| 1 | 0.040 | 0.040 | 9.60×10^{-6} |
| 2 | 0.080 | 0.040 | 1.92×10^{-5} |
| 3 | 0.080 | 0.020 | 9.60×10^{-6} |

- (i) Determine the rate law for this reaction.
- (ii) Find the rate constant k .
- (iii) Determine the initial rate of reaction when $[A]_0 = 0.120 \text{ M}$ and $[B]_0 = 0.015 \text{ M}$. (5 marks)
- (c) (i) Illustrate the electronic configuration of Mg^{2+} ion and justify if it possess a paramagnetic or diamagnetic properties. (5 marks)
- (ii) Determine the number of electron permitted in the subshell in d orbital with principal quantum number of 3. Justify your answer and list down all the quantum numbers. (5 marks)
- Q5** (a) (i) Determine if the elements in the compounds NaCl and SO_2 are metal or non-metals. Identify the type of bonding that occurs in the compounds. (3 marks)
- (ii) Draw the dot structures for each of the compounds C_2Cl_2 and SO_4^{2-} (your answers must include atomic number and electron valens for each elements). (7 marks)
- (b) (i) Calculate the standard enthalpy change for the reaction below;



Given that



(5 marks)

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- (ii) Consider the reaction below;



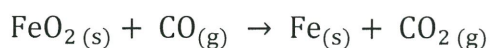
If 3 mole of H_2 reacts with 3 mole of Cl_2 to form HCl . By assuming that the reaction goes to completion, calculate the ΔE against pressure of 1 atm at 25°C .

(5 marks)

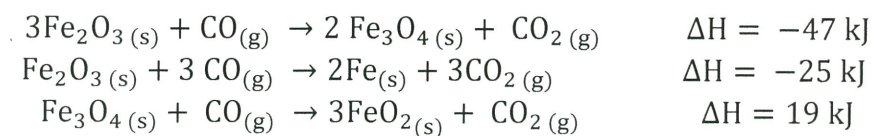
- Q6 (a) Draw the resonance form of BF_3 and show the formal charge of each atom.

(10 marks)

- (b) One reaction involved in the conversion of iron ore to the metal is



Assuming the equation above is a balanced equation, calculate the standard enthalpy changes for this reaction from these reactions of iron oxides with CO . Determine and justify if it is an exothermic or endothermic reaction.



(10 marks)

– END OF QUESTIONS –

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Gas constant values with different units

| <i>R</i> | Unit |
|----------------------|--------------------------|
| 0.0821 | L.atm/mol.K |
| 8.3145×10^3 | L.Pa/mol.K |
| 8.3145 | J/K.mol |
| 8.3145 | m ³ .Pa/K.mol |

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Atomic number and mass of atoms

| Element | Symbol | Atomic number (Z) | Atomic mass (A) | Element | Symbol | Atomic number (Z) | Atomic mass (A) |
|-------------|--------|-------------------|-----------------|--------------|--------|-------------------|-----------------|
| Actinium | Ac | 89 | 227.0278 | Mercury | Hg | 80 | 200.59 |
| Aluminum | Al | 13 | 26.98154 | Molybdenum | Mo | 42 | 95.94 |
| Americium | Am | 95 | (243) | Neodymium | Nd | 60 | 144.24 |
| Antimony | Sb | 51 | 121.75 | Neon | Ne | 10 | 20.179 |
| Argon | Ar | 18 | 39.948 | Neptunium | Np | 93 | 237.0482 |
| Arsenic | As | 33 | 74.92160 | Nickel | Ni | 28 | 58.7 |
| Astatine | At | 85 | (210) | Niobium | Nb | 41 | 92.9064 |
| Barium | Ba | 56 | 137.33 | Nitrogen | N | 7 | 14.0067 |
| Berkelium | Bk | 97 | (247) | Nobelium | No | 102 | (259) |
| Beryllium | Be | 4 | 9.01218 | Osmium | Os | 76 | 190.2 |
| Bismuth | Bi | 83 | 208.9804 | Oxygen | O | 8 | 15.9994 |
| Boron | B | 5 | 10.81 | Palladium | Pd | 46 | 106.4 |
| Bromine | Br | 35 | 79.904 | Phosphorus | P | 15 | 30.97376 |
| Cadmium | Cd | 48 | 112.41 | Platinum | Pt | 78 | 195.09 |
| Calcium | Ca | 20 | 40.08 | Plutonium | Pu | 94 | (244) |
| Californium | Cf | 98 | (251) | Polonium | Po | 84 | (209) |
| Carbon | C | 6 | 12.011 | Potassium | K | 19 | 39.0983 |
| Cerium | Ce | 58 | 140.12 | Praseodymium | Pr | 59 | 140.9077 |
| Cesium | Cs | 55 | 132.9054 | Promethium | Pm | 61 | (145) |
| Chlorine | Cl | 17 | 35.453 | Protactinium | Pa | 91 | 231.0359 |
| Chromium | Cr | 24 | 51.996 | Radium | Ra | 88 | 226.0254 |
| Cobalt | Co | 27 | 58.9332 | Radon | Rn | 86 | (222) |
| Copper | Cu | 29 | 63.546 | Rhenium | Re | 75 | 186.207 |
| Curium | Cm | 96 | (247) | Rhodium | Rh | 45 | 102.9055 |
| Dysprosium | Dy | 66 | 162.50 | Rubidium | Rb | 37 | 85.4678 |
| Einsteinium | Es | 99 | (254) | Ruthenium | Ru | 44 | 101.07 |
| Erbium | Er | 68 | 167.26 | Samarium | Sm | 62 | 150.4 |
| Europium | Eu | 63 | 151.96 | Scandium | Sc | 21 | 44.9559 |
| Fermium | Fm | 100 | (257) | Selenium | Se | 34 | 78.96 |
| Fluorine | F | 9 | 18.998403 | Silicon | Si | 14 | 28.0855 |
| Francium | Fr | 87 | (223) | Silver | Ag | 47 | 107.868 |
| Gadolinium | Gd | 64 | 157.25 | Sodium | Na | 11 | 22.98977 |
| Gallium | Ga | 31 | 69.72 | Strontium | Sr | 38 | 87.62 |
| Germanium | Ge | 32 | 72.59 | Sulfur | S | 16 | 32.06 |
| Gold | Au | 79 | 196.9665 | Tantalum | Ta | 73 | 180.9479 |
| Hafnium | Hf | 72 | 178.49 | Technetium | Tc | 43 | (97) |
| Helium | He | 2 | 4.00260 | Tellurium | Te | 52 | 127.60 |
| Holmium | Ho | 67 | 164.9304 | Terbium | Tb | 65 | 158.9254 |
| Hydrogen | H | 1 | 1.0079 | Thallium | Tl | 81 | 204.37 |
| Indium | In | 49 | 114.82 | Thorium | Th | 90 | 232.0381 |
| Iodine | I | 53 | 126.9045 | Thulium | Tm | 69 | 168.9342 |
| Iridium | Ir | 77 | 192.22 | Tin | Sn | 50 | 118.69 |
| Iron | Fe | 26 | 55.847 | Titanium | Ti | 22 | 47.90 |
| Krypton | Kr | 36 | 83.80 | Tungsten | W | 74 | 183.85 |
| Lanthanum | La | 57 | 138.9055 | Uranium | U | 92 | 238.029 |
| Lawrencium | Lr | 103 | (260) | Vanadium | V | 23 | 50.9414 |
| Lead | Pb | 82 | 207.2 | Xenon | Xe | 54 | 131.30 |
| Lithium | Li | 3 | 6.941 | Ytterbium | Yb | 70 | 173.04 |
| Lutetium | Lu | 71 | 174.97 | Yttrium | Y | 39 | 88.9059 |
| Magnesium | Mg | 12 | 24.305 | Zinc | Zn | 30 | 65.38 |
| Manganese | Mn | 25 | 54.9380 | Zirconium | Zr | 40 | 91.22 |
| Mendelevium | Md | 101 | (258) | | | | |

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