MELBOURNE HIGH SCHOOL

UNIT 4 CHEMISTRY

Name: _____

TRIAL EXAMINATION

Group: _____

2010

Teacher: _____

QUESTION AND ANSWER BOOKLET

Wednesday 15th September 2010
Reading time : 15 minutes
Writing time : 90 minutes

Section	*Number of questions*	*Number of questions to be answered*	Number of marks	Suggested time (minutes)
A	20	20	20	23
B	9	9	60	67
		Total	80	90

Materials : * Question and answer booklet consisting of a cover page and 14 pages of questions - pages are numbered 2 to 15
* Answer sheet for multiple-choice questions.

Instructions : * Multiple choice items are to be answered by filling in the appropriate box which corresponds to the answer of your choice in the question booklet.
* Short answer questions are to be answered in the spaces provided.
* All written responses must be in English.
* Chemical equations and half equations must include symbols of state.
* Numerical answers are to be given to appropriate numbers of significant figures.
* A unit must be given in numerical answers that require a unit for complete specification.
Students must bring in to the examination their own clean, stapled copy of the relevant pages of the data book.
* Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, and a scientific calculator.
* **Students are NOT permitted to bring graphics calculators, mobile phones and/or any other electronic communication devices, or blank sheets of paper or white out liquid/tape into the examination room**.

Submission : * At the conclusion of the exam, place your Multiple Choice answer sheet inside this booklet.

Section A / 20

Section B / 60

Total / 80

4exam2010

2010 UNIT 4 - SECTION A

Specific instructions for Section A

- This section consists of 20 multiple choice items which are to be answered by shading the box on the answer sheet that corresponds to your answer in **lead pencil**.
- A correct answer scores 1 mark and an incorrect answer scores 0 marks.
- 1 × 20 = 20 marks, 23 minutes

1 When a reaction mixture is heated, the rate of reaction increases. This occurs because:

A the extra heat lowers the activation energy for the reaction so that more collisions are successful.
B the reactants expand so that the increased surface area results in greater contact between the reactants.
C the extra heat weakens the bonds in the reactant species enabling the bonds to break more easily.
D a greater proportion of the collisions have a combined energy that exceeds the activation energy for the reaction.

2 Consider the equilibrium associated with the production of hydrogen cyanide gas:

$$2CO(g) + NH_3(g) \rightleftharpoons HCN(g) + CO_2(g) + H_2(g) \quad \Delta H = +19 \text{ kJ mol}^{-1}$$

Which one of the following changes will always result in an improved yield of hydrogen cyanide from ammonia?

A increasing the mole ratio of CO to NH_3 in the feedstock gases.
B increasing the applied pressure.
C replacing the existing catalyst with a more efficient one.
D lowering the temperature of reaction mixture.

*** ***The next 3 items (Q3 to 5) refer to the following information:***

The hydrolysis of the ammonium ion is given by:

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

3 The relationship between the equilibrium constant, K_c, and the acidity constant, K_a, for this reaction is:

A K_c and K_a have identical expressions but are used in different contexts.
B $K_a = K_w \div K_c$.
C $K_a = K_c \times [H_2O]$.
D $K_a = K_c \div [H_2O]$.

4 The pH of a 0.20 M solution of ammonium chloride would be:

A 0.7.
B 4.6.
C 5.0.
D 9.9.

5 400 mL of water is added to 100 mL of an ammonium ion solution at constant temperature. As a result of the dilution, the

A $[H_3O^+]$ in the solution increases.
B K_a of the acid increases.
C K_a of the acid decreases.
D pH of the solution increases.

6 At very high temperatures (at least 1500 K) nitrogen reacts with oxygen thus:

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

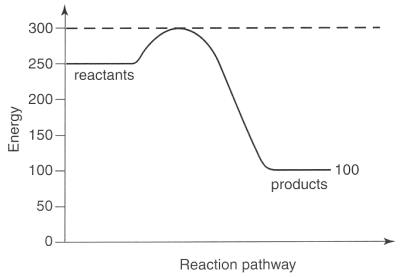
At a particular temperature, T K (where T > 1500), when the system had reached equilibrium, the concentrations of the gases were found to be $[N_2] = 0.025$ M, $[O_2] = 0.16$ M and $[NO] = 4.0$ M. The equilibrium constant for this reaction at T K is:

A 2.5×10^{-4}.
B 1.0×10^{-3} M^{-1}.
C 1.0×10^{3} M.
D 4.0×10^{3}.

7 The self-ionisation constant of pure water at 55°C is $7.29 \times 10^{-14} M^2$. The hydroxide ion concentration and pH will be respectively,

A 1.0×10^{-7}M and 6.57
B 1.0×10^{-7}M and 7.00
C 2.7×10^{-7}M and 6.57
D 2.7×10^{-7}M and 7.00

8 The following energy profile represents the relative enthalpies of the reactants and products of a chemical reaction.



The numerical value of the enthalpy change, ΔH, for the reverse reaction is

A +200
B +150
C -200
D -150

9 Consider the thermochemical equation

$$H_2O(l) \rightarrow H_2O(g) \qquad \Delta H = +44 \text{ kJ mol}^{-1}$$

When 9.0 g of water condenses,

A 22 kJ of energy will be absorbed.
B 22 kJ of energy will be released.
C 44 kJ of energy will be absorbed.
D 44 kJ of energy will be released.

10 Sulfuric acid is used in many preparative reactions. Two of these are the production of superphosphate and esters. In these two reactions, sulfuric acid acts as, respectively:

A a dehydrating agent and a strong acid.
B an oxidant and a dehydrating agent.
C a strong acid and a dehydrating agent.
D a dehydrating agent and an oxidant.

11 The following table contains some features associated with calorimeters:

	Feature
I	electrical heating element
II	metal container for a reactant solution
III	thermometer or other temperature sensing device
IV	water bath surrounding the reaction chamber

Which one of the following lists contains all those features not common to both bomb calorimeters and solution (constant pressure) calorimeters?

A IV only
B I and III only
C II and IV only
D I, II and IV only

12 Which one of the following reactions releases the largest amount of energy per mole of the reactant shown in **bold** letters?

A $\mathbf{2Cl_2(g)} + O_2(g) \rightarrow 2ClO_2(g)$ $\Delta H = +80$ kJ mol^{-1}
B $Fe_2O_3(s) + 3\mathbf{CO(g)} \rightarrow 2Fe(s) + 3CO_2(g)$ $\Delta H = -25$ kJmol^{-1}
C $\mathbf{H_2(g)} + CO_2(g) \rightarrow H_2O(g) + CO(g)$ $\Delta H = +42$ kJ mol^{-1}
D $3Zn(s) + \mathbf{N_2(g)} \rightarrow Zn_3N_2(s)$ $\Delta H = -23$ kJ mol^{-1}

13 A cell composed of a standard iodine half cell ($I_2(aq)/I^-(aq)$) and another standard half cell is required to produce at least 1.55 V. The other standard half cell is the anode. The second standard half cell could be:

A $Au^+(aq)/Au(s)$ half cell.
B $F_2(g)/F^-(aq)$ half cell.
C $Mn^{2+}(aq)/Mn(s)$ half cell.
D $Ni^{2+}(aq)/Ni(s)$ half cell.

14 An electric current is passed through a dilute solution of potassium chloride. The gas produced at the cathode would be:

A chlorine.
B hydrogen.
C oxygen.
D nothing as there is no gas produced at the cathode.

***** The following information refers to Items 15 and 16:**

The reactions occurring when a Nicad cell is being charged are:

$$Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$$
$$Ni(OH)_2(s) + OH^-(aq) \rightarrow Ni(OH)_3(s) + e^-$$

15 During the charging process,

A $Cd(OH)_2$ is oxidised to Cd.
B more OH^- ions are produced than consumed.
C Cd is formed at the positive electrode.
D $Ni(OH)_2$ is oxidised to $Ni(OH)_3$.

16 When current is being drawn from the Nicad cell,

A $Cd(OH)_2$ is precipitated.
B $Cd(OH)_2$ is reduced.
C $Ni(OH)_3$ is precipitated.
D the nickel electrode is the anode.

17 The pH of the electrolyte solution in a car battery is higher in a 'flat' battery than in a fully charged one. This is because:

A the reaction that produces the electric current also produces hydroxide ions so that the pH increases as the reaction occurs.
B the insoluble $PbSO_4$ that forms on the plates removes sulfate ions from the electrolyte.
C the charging reaction in a lead-acid accumulator consumes sulfuric acid.
D the hydrogen ions in the electrolyte are consumed as the lead (IV) oxide is reduced.

18 Which one of the following chemical equations would best describe the overall reaction that occurs during the electrolysis of a dilute aqueous solution of sodium chloride using platinum electrodes?

A $2H_2O(l) + 2Cl^-(aq) \rightarrow H_2(g) + Cl_2(g) + 2OH^-(aq)$
B $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$
C $2H_2O(l) + Pt(s) \rightarrow H_2(g) + 2OH^-(aq) + Pt^{2+}(aq)$
D $2Na^+(aq) + 2Cl^-(aq) \rightarrow 2Na(s) + Cl_2(g)$

19. The E^o for the half cell $Q^{2+}(aq)/Q^+(aq)$ is +0.50 V and the E^o for the half cell $R^{3+}(aq)/R^+(aq)$ is -0.50 V. The expected emf of a cell composed of these two standard half cells would be:

A 0.00 V.
B 0.50 V.
C 1.00 V.
D 1.50 V.

20. An iron object is to be plated with tin. The iron object is the cathode in an electrolytic cell and the anode is pure tin metal. The electrolyte solution is $K_2Sn(OH)_6$. Which one of the following statements about this electrolytic cell is **incorrect**?

A. The cathode reaction is $Sn(OH)_6^{2-}(aq) + 4e^- \rightarrow Sn(s) + 6OH^-(aq)$.
B. The anode is the positive electrode.
C. The K^+ ions migrate towards the anode as electroplating takes place.
D. The net result of the electrolysis is to transfer tin from the anode to the cathode.

2010 UNIT 4 SECTION B

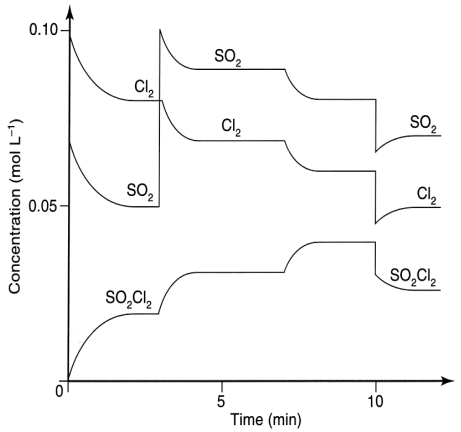
Specific instructions for Section B

- This section consists of ***9*** short answer questions which are to be answered in the spaces provided.
- Numerical answers must be given to the appropriate number of significant figures.
- Symbols of state must be included in all equations and half equations.
- No credit will be given for an incorrect numerical answer unless it is supported by working.
- ***60*** marks, 67 minutes

1 [11 marks, 12 minutes]
Sulfur dioxide gas and chlorine gas were mixed at a particular temperature to produce a gaseous equilibrium mixture:

$$SO_2(g) + Cl_2(g) \rightleftharpoons SO_2Cl_2(g) \qquad \Delta H = -67 \text{ kJ mol}^{-1}$$

For a particular experiment, the concentrations of the three substances are plotted against time in the graph below.



a Write the expression for the equilibrium constant K of the reaction.

b During which time intervals was the reaction proceeding in the forward direction?

c Calculate the value of K at the 2 minute and 9 minute marks.
i at 2 minutes

ii at 9 minutes

d State one possible reason why the values for K calculated in c above are different.

_____

e What change was made to the system at

i 3 minutes _____

ii 7 minutes _____

iii 10 minutes _____

f Circle the correct alternative:
Compared with the energy of the reactants, the chemical energy of the product, SO_2Cl_2, will be

higher / lower

and the activation energy for the forward reaction will be

higher / lower

than the activation for the backward reaction.

g Explain how you could change temperature and volume to produce the highest percentage yield.

_____

_____

_____

_____

(1 + 1 + (1 + 1) + 1 + (1 + 1 + 1) + (½ + ½) + 2 = 11 marks)

2 [9 marks, 12 minutes]
The equilibrium constant for a chemical reaction occurring at a fixed temperature with gaseous reactants and products can be expressed as

$$K = \frac{[A]^2[B]}{[C][D]^3} = 7.46 \times 10^5\ M^{-1}$$

a Write a balanced chemical equation for the reaction involving gases A, B, C and D.

_____

b What does the value of this equilibrium constant indicate about the rate of this chemical reaction?

_____

_____

c What does the value of this equilibrium constant indicate about the ratio of reactants to products when this reaction mixture is at equilibrium?

_____

_____

d Some additional gas C is added to the equilibrium mixture. State the effect this will have on the value of K.

_____

_____

e This reaction is exothermic. What effect will an increase in temperature have on the value of K? Explain your answer.

_____

_____

f Under a different set of temperature conditions, a 2.0 L vessel containing 0.5 mol of gas C and 0.750 mol of gas D are allowed to reach equilibrium. The amount, in mol, of gas B present at equilibrium is found to be 0.15 mol. Calculate the value of K at this temperature.

(2 + 1 + 1 + 1 + 1 + 3 = 9 marks)

3 [5 marks, 5 minutes]
An equilibrium mixture contains the gases Cl_2, F_2 and ClF_3.

a A sample of argon is added to the mixture. State the effect of adding argon on the amount of ClF_3 present.

_____

b The gas mixture is transferred to a new container that has half the volume of the original container. State the effect of this change in volume on the amount of ClF_3 present.
Explain your answer.

_____

_____

_____

_____

c Calculate the initial concentration in mol/L, of benzoic acid that is required to produce an aqueous solution of benzoic acid that has a pH of 2.54.

(1 + 2 + 2 = 5 marks)

4 [5 marks, 5 minutes]
The industrial production of a chemical, E, from a starting material, A, was carried out in three stages as described by the chemical equations:

1. $4A(g) + 5O_2(g) \rightarrow 4B(g) + 6H_2O(g)$ $\Delta H = -907\ kJmol^{-1}$
2. $2B(g) + O_2(g) \rightarrow 2D(g)$ $\Delta H = -114\ kJmol^{-1}$
3. $3D(g) + H_2O(l) \rightarrow 2E(aq) + B(g)$ $\Delta H = +137\ kJmol^{-1}$

a Why would a catalyst be used in the first stage of this process?

_____

_____

b The gases exiting the first stage of the process are at about 900°C. These are cooled to about 50 °C and mixed with air (oxygen) before being compressed. Explain how these changes would affect the equilibrium yield of the second stage.

_____

_____

_____

_____

c How would the plant deal with any waste gases produced in the third stage of the process?

_____

_____

d Some chemical reactions such as those in the first stage of this process are exothermic and cooling is required before further use. What is one way that a chemical plant may use the energy released by these reactions?

_____

_____

(1 + 2 + 1 + 1 = 5 marks)

5 [5 marks, 6 minutes]
When 1.00 g of pure liquid heptane (C_7H_{16}) is burnt in a suitable apparatus, the rise in temperature is 5.71 K. The calibration factor of the apparatus is known to be 8.50 kJ K^{-1}.

a Heats of combustion are always positive yet ΔH for a combustion reaction is always negative. Why?

_____

_____

_____

_____

_____

_____

b Write the equation for the complete combustion of heptane.

_____

c Calculate the heat of combustion of heptane.

(2 + 1 + 2 = 5 marks)

6 [8 marks, 8 minutes]

a When measuring the heat of solution of a solid using a calorimeter, it is standard practice to have the solid finely divided. Why is this the case?

_____

_____

b A rough guide to fuel efficiency is the amount of energy evolved from the complete combustion of 1.00 g of fuel. Petrol (assumed to be pure octane) and methofuel (a methanol based fuel) are being compared in this way.

i. Given that:

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l) \quad \Delta H = -1.09 \times 10^4 \text{ kJ mol}^{-1},$$

calculate the energy released during the combustion of 1.00 g of octane.

ii. Methofuel was burnt in a bomb calorimeter and the following results were obtained:

calibration factor (calorimeter constant) of the calorimeter	-	1.27 kJ $^oC^{-1}$
mass of methofuel used	-	1.30 g
temperature of calorimeter setup and contents before combustion	-	18.7 ^oC
temperature of calorimeter setup and contents after combustion	-	41.9 ^oC

Calculate the energy released during the combustion of 1.00 g of methofuel.

iii. On the basis of these results, which fuel is more efficient? _____

iv. Methanol may be produced from cellulose. What long term advantage would methofuel have over petrol?

_____

_____

_____

(1 + (2 + 3 + 1 + 1) = 8 marks)

7 [5 marks, 5 minutes]
A galvanic cell is composed of a standard zinc half cell coupled with a standard half cell containing acidified sodium bromate solution. The cell reaction is:

$$5Zn(s) + 2BrO_3^-(aq) + 12H^+(aq) \rightarrow 5Zn^{2+}(aq) + Br_2(l) + 6H_2O(l)$$

a With reference to the zinc half cell, explain what is meant by the term **standard half cell.**

_____

_____

_____

b Determine the half equation for the cathode reaction.

_____

c What is the polarity of the cathode when the cell is producing current? _____

d Suggest a chemically suitable substance (including its state) for use
i) in the salt bridge of the cell:

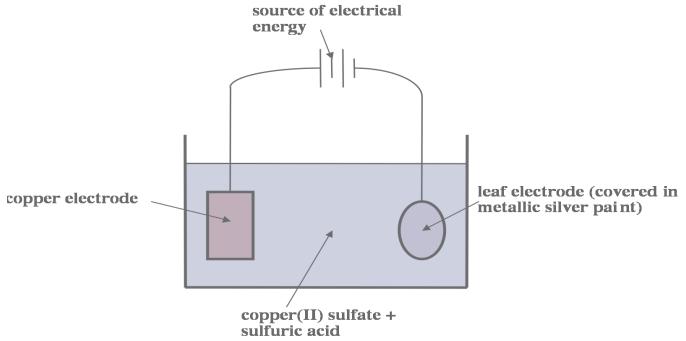
_____

ii) as the electrode in the bromate half cell:

_____

(1 + 1 + 1 + (1 + 1) = 5 marks

8 [7 marks, 8 minutes]
In the electrolytic cell shown below, decorative copper leaf jewellery can be produced. The leaf is coated with silver metallic paint and forms one of the electrodes. The other electrode is pure copper metal. The electrolyte is a 1M aqueous solution of copper(II) sulfate in 2M sulfuric acid.



a Write the balanced chemical equation for the reduction reaction in this electrolysis.

_____

b Write the balanced chemical equation for the oxidation reaction in this electrolysis.

_____

c Identify the anode in this cell

_____

d Explain why the leaf is coated with metallic silver paint.

_____

_____

_____

_____

_____

e Does any change occur in the concentration of copper(II) ions in the solution during the electroplating? Explain your answer.

_____

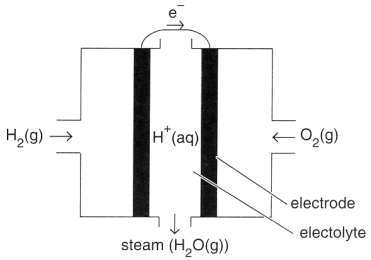
_____

_____

_____

(1 + 1 + 1 + 2 + 2 = 7 marks)

9 [5 marks, 6 minutes]
About 85% of the electricity generated in Victoria is produced in coal-fired power stations.
A possible alternative energy source for the production of electricity is the fuel cell. A simplified diagram of the hydrogen-oxygen fuel cell is shown below.



a Write the balance half equation for the reaction occurring at the anode.

b Identify two features of a fuel cell that distinguish it from a galvanic cell.

c State two disadvantages, associated with the fuel cell, that explains why it is not a major source of electricity.

d. Nuclear fission reactors can be used to generate electricity.
Describe one advantage of generating electricity from nuclear fission over coal-fired power stations.

(1 + 1 + 2 + 1 = 5 marks)

END of PAPER