MELBOURNE HIGH SCHOOL

UNIT 4 CHEMISTRY

TRIAL EXAMINATION

2008

QUESTION AND ANSWER BOOKLET

Friday 19th September 2008
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	63	67
		Total	83	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 a clean, stapled copy 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 into the examination room, blank sheets of paper, white out liquid/tape**.

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

Section A / 20

Section B / 63

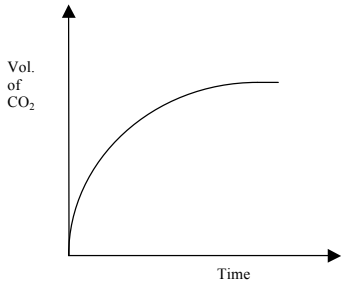
Total / 83

2008 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 The reaction between excess calcium carbonate and hydrochloric acid can be followed by measuring the volume of carbon dioxide produced over time. The results of one such reaction are shown below. How does the rate of this reaction change with time and what is the main reason for this change?



A The rate increases with time because the calcium carbonate particles get smaller.
B The rate increases with time because the acid becomes more dilute.
C The rate decreases with time because the calcium carbonate particles get smaller.
D The rate decreases with time because the acid becomes more dilute.

2 The rate of reaction of a strip of magnesium and 50 cm^3 of 1.0 $mol.dm^{-3}$ of HCl is determined at 25°C. In which situation would both new conditions contribute to an increase in the rate of the reaction?

A Mg powder and 100 cm^3 of 1.0 mol dm^{-3} of HCl
B Mg powder and 50 cm^3 of 0.8 mol dm^{-3} of HCl
C 100 cm^3 of 1.0 mol dm^{-3} of HCl at 30 °C
D 50 cm^3 of 1.2 mol dm^{-3} of HCl at 30 °C

3 Some collisions between reactant molecules do not form products. This is because

A The molecules do not collide in the proper ratio
B The molecules do not have sufficient energy
C The concentration of reactant molecules is too low
D The reaction is at equilibrium

4 The rate determining step in a reaction is the

A Fastest step in the reaction
B First step in the reaction
C Final step in the reaction
D Step with the highest activation energy

3

5 Ethanol is manufactured from ethene using the reaction below:

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g) \qquad \Delta H = -46 \text{ kJ/mol.}$$

Which conditions favour the highest yield of ethanol?

A High pressure and low temperature
B High pressure and high temperature
C low pressure and low temperature
D low pressure and high temperature

6 Which of the following reagents could not be added together to make a buffer solution?

A NaOH (aq) and CH_3COOH(aq)
B CH_3COONa(aq) and CH_3COOH(aq)
C NaOH (aq) and CH_3COONa(aq)
D NH_4Cl(aq) and NH_3 (aq)

7 The following information refers to questions 7, 8 and 9
Nitrous acid ionises in water according to the following equation

$$HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$$

450 ml of water is added to 50 ml of nitrous acid at constant temperature.

The acidity constant, K_a for nitrous acid is given by

A $\dfrac{[H_3O^+][NO_2^-]}{[HNO_2][H_2O]}$

B $\dfrac{[H_3O^+][NO_2^-]}{[HNO_2]}$

C $\dfrac{[HNO_2][H_2O]}{[H_3O^+][NO_2^-]}$

D $\dfrac{[HNO_2]}{[H_3O^+][NO_2^-]}$.

8 As a result of the dilution, the

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

9 As a result of the dilution, the amount in mole of

A HNO_2 in solution increases
B H_3O^+ in solution increases
C H_3O^+ in solution decreases
D NO_2^- in solution remains constant

4

10 The self ionisation of water is an endothermic reaction.
The equilibrium constant K_w at 25 °C is 10^{-14}.
The pH of pure water at 0 °C is

A Slightly below 7.0 and the water is neutral
B 7.0 and the water is slightly acidic
C Slightly above 7.0 and the water is basic
D Slightly above 7.0 and the water is neutral

The following information refers to Questions 11 and 12.

When current is drawn from a lead-acid accumulator, the electrode reactions are

$$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$$
$$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$

11 In the net cell reaction, the changes in the oxidation states of the lead species are from:

A 0 and +4 to +2.
B +2 to +4.
C 0 to -2 and -4.
D +2 to 0 and +4.

12 As current is drawn from the accumulator, the sulfuric concentration

A increases
B remains unchanged
C decreases
D the direction of change cannot be determined.

13 When the accumulator is recharged by passing a current through it in the reverse direction

A lead dioxide is converted to lead metal
B lead sulphate is converted to lead metal and lead dioxide
C lead metal is converted to lead sulphate
D water is formed as charging proceeds

The following information refers to Questions 14,15 and 16.

The heat energy produced during the combustion of 2 mol of carbon monoxide according to the equation

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \qquad \Delta H = -564 \text{ kJ mol}^{-1}$$

14 This reaction is exothermic because

A bonds are only formed so heat energy must be evolved.
B the heat of content of the products
C the surroundings supply heat to the system.
D the net bond strength of the products is greater than that of the reactants.

15 The heat energy produced during the combustion of 2 mol of carbon monoxide according to the equation

$$2CO(g) + O_2(g) \rightarrow 2CO_2(s)$$

would be

A less than 564 kJ.
B 564 kJ.
C greater than 564 kJ.
D unable to be deduced as there is insufficient information.

16 The amount of heat energy produced when 5.60g of carbon monoxide gas is burnt in excess oxygen to form gaseous carbon dioxide is

A 28.2 kJ
B 56.4 kJ
C 113 kJ
D 564 kJ

17 The process used for preparing pure copper in commercial quantities involves essentially the electrolysis of copper sulfate solution using copper electrodes. During this process

A copper metal is deposited on the positive electrode.
B copper ions migrate towards the anode.
C hydrogen gas is given off at the negative electrode.
D the mass of the anode decreases.

18 Powdered aluminium burns in oxygen according to the equation:

$$2Al(s) + {}^3/_2\, O_2(g) \rightarrow Al_2O_3(s) \qquad \Delta H = -1674 \text{ kJ mol}^{-1}$$

When 0.500 mol of aluminium burns according to the equation above,

A 837 kJ of heat is released
B 837 kJ of heat is absorbed
C 418.8 kJ of heat is released
D 418.5 kJ of heat is absorbed

19 Ce^{4+} will oxidize HCl. Br_2 will oxidize Fe^{2+}. Cl_2 will oxidize HBr. Fe^{3+} will oxidize HI. It follows that Fe^{2+} may be oxidized by:

A Cl_2 and I_2 but not by Ce^{4+}.
B Ce^{4+} and I_2 but not Cl_2.
C Ce^{4+} and Cl_2 but not I_2.
D Ce^{4+} but not by Ce^{4+} or I_2.

20 Potassium is obtained commercially by the electrolysis of molten potassium chloride. Potassium cannot be obtained by passing a current through an aqueous solution of potassium chloride because:

A hydrogen, rather than potassium, would be produced at the cathode.
B oxygen would be produced in the cell in preference to chlorine and this would oxidize the potassium.
C potassium is a weaker reductant than hydrogen.
D oxygen and not potassium would be produced at the cathode.

2008 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.
- ***63*** marks, 67 minutes

1a Methanol CH_3OH can be used as a fuel. The reaction for the commercial production of methanol is represented by the equation

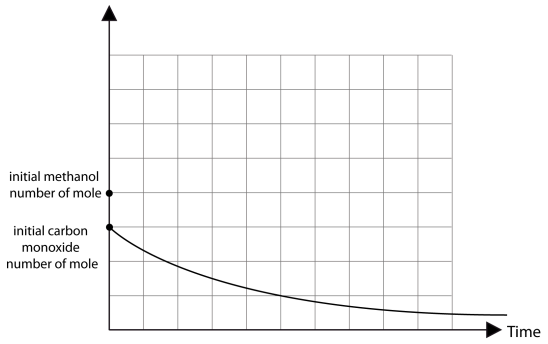
$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -90 \text{ kJ mol}^{-1}$$

The following changes are made to a gaseous equilibrium mixture of CO, H_2 and CH_3OH at 300°C. Indicate in the table below the effects on the masses of CO, H_2 and CH_3OH present at equilibrium by entering the words "increase", "decrease" or "no change" as appropriate

.

change	Effect on mass of CO at equilibrium	Effect on mass of H_2 at equilibrium	Effect on mass of CH_3OH at equilibrium
More H_2 is added at constant temperature and volume			
The volume of the vessel is increased at constant temperature			
The temperature is increased at constant volume			

b The following graph represents the change in the number of mole of carbon monoxide with time during which the volume of the vessel is changed at constant temperature. On this graph sketch and label a line showing how the number of mole of methanol would have changed over the same period.



(9 x ½ + ½ = 5 marks)

7

2 In a reaction specified by the equation:

$$2A(g) \rightleftharpoons 2B(g) + C(g)$$

3.5 mol. of substance A is initially introduced into a 500 mL reaction vessel and allowed to reach equilibrium. At this stage its concentration was found to be 2.0 M.
Calculate the equilibrium constant for this reaction.

(5 marks)

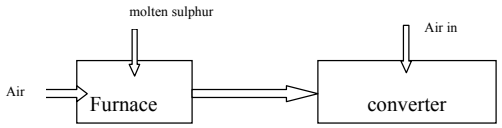
3a Calculate the pH of a 0.10 M solution of benzoic acid C_6H_5COOH given that the K_a value for this acid is 6.3×10^{-5} mol L^{-1}

b Determine the percentage ionisation of the benzoic acid solution

(3 + 2 = 5 marks)

8

4 Below is a schematic showing the first two stages in the production of sulfuric acid



Give the equation for:

ai the reaction occurring in the furnace

aii The reaction occurring in the converter

b The reaction that occurs in the converter is exothermic. State two conditions that will maximise the amount of desired product.

A catalyst is used in the converter.

ci What is the name of this catalyst ?

cii What role does this catalyst play?

ciii Suggest one means by which the effectiveness of the catalyst can be improved

9

The final stages of the contact process involve the production of oleum and the production of sulfuric acid.

di Show the equation for the production of oleum

dii Show the equation for the production of sulfuric acid

Sulfuric acid is used in a number of industrial processes and can undergo a number of different reactions.

e Write an equation showing the sulfuric acid acting as an oxidant

When shipped for use in laboratories or industrial plants, a MSDS accompanies the sulfuric acid. Give one health hazard associated with exposure to sulfuric acid and one precaution for use:

fi Health hazard

fii Precaution for use

((1 + 1) + 2 + (1 + 1 +1) + (1 + 1) +1 + (1 + 1) = 12 marks)

10

5 Most of Victoria's electricity is obtained from coal-burning plants at Loy Yang.

a) What is a fossil fuel?

b) What are the advantages and disadvantages of use of coal for the large scale generation of electric power?

c) France, in comparison, uses nuclear power to generate electric power.
Draw an energy transfer diagram for the conversion of nuclear energy to electric energy.

(1 + 2 + 2 = 5 marks)

6 A solution of 1.0 M chromium II chloride is placed in a beaker (beaker A) with a strip of chromium metal. A second beaker (beaker B) contains a platinum wire dipping into a solution which is 1.0 M cobalt II chloride and 1.0 M cobalt III chloride. Solution contact between the two beakers is achieved by means of a potassium nitrate salt bridge.
A third beaker (beaker C) has a copper rod and a carbon rod dipping into a solution of manganese II sulphate. The copper rod and the carbon rod are not in direct contact with each other.

Wires are used to join the chromium strip to the carbon rod and, separately, the platinum wire to the copper rod.

Extra data: $Cr^{2+}(aq) + 2e \rightarrow Cr(s)$ $E° = -0.56$ V
$Co^{3+}(aq) + e \rightarrow Co^{2+}(aq)$ $E° = +1.84$ V

a) Draw a clearly labelled diagram of the entire assembly. Show electron flow.

b) Write overall equations to account for the chemical changes that occur in all three beakers at the instant that the circuit is completed.

Beaker A:

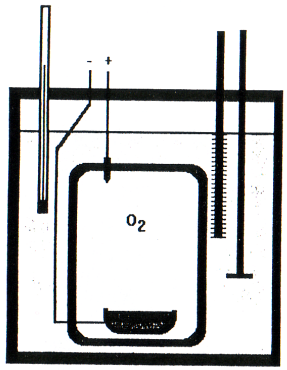
Beaker B:

Beaker C:

(4 + 3 = 7 marks)

7a) 50.0 g of water at 63.9 °C was poured into a calorimeter containing 50.0 g water at 21.2 °C. The final temperature was measured to be 42.3°C. Calculate the heat lost to the surroundings.

b) The heat of combustion of sucrose, a disaccharide can be determined by using a bomb calorimeter (shown below).



In one experiment, a current of 2.50 A was passed through the electric heater of a bomb calorimeter for 60.0 seconds at a voltage of 5.50V causing a temperature rise of 0.529°C.

0.346g of sucrose was reacted with excess oxygen in the calorimeter according to the equation:

$$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l)$$

The temperature rose from 19.106°C to 22.726°C.

(i) Calculate the calibration factor for this calorimeter.

(ii) Calculate the ΔH for the combustion of sucrose.

(iii) Explain why the calculated value of ΔH for this reaction may differ from the published value of ΔH.

(iv) Electrical energy (in the form of a spark) needs to be added to the reactants for the reaction to start. What is this energy called?

(v) Explain the purpose of this added energy in terms of molecules.

(3 + (2 + 3 + 1 + 1 + 1) = 11 marks)

8 Every time you use a Bunsen Burner you witness the reaction of methane (CH_4) in oxygen to produce carbon dioxide and water. The thermal energy released is used to heat substances. It is quite possible for the methane/oxygen reaction to be accomplished in the form of a fuel cell, the energy appearing as electrical energy.

a) Make a simple labelled diagram of such a fuel cell mentioning the important materials you would need to use and indicating the polarity of the electrodes. (**assume an acidic electrolyte)**

b) Give the overall reaction that occurs when this fuel cell releases electricity.

c) Give the half cell reactions.

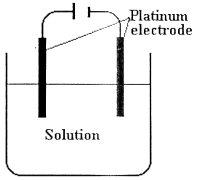
At the anode: _____

At the cathode: _____

d) Methane can also be used as the fuel in a conventional power station. Comment on the efficiency of the fuel cell compared with that of the corresponding combustion process.

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

9 A mixture of magnesium chloride and copper (II) chloride in solution is prepared so that each chemical is at an initial concentration of 0.25 M.
Platinum electrodes are inserted into the solution and a small current is passed through it.



a Write half equations for the main electrode reactions occurring just after the electrolysis is started.

At the anode:

At the cathode:

b Write a half equation for the main electrode reaction occurring much later.
At the cathode:

The heat value of a typical fat, stearin, may be represented by the equation:

$2\ C_{57}H_{110}O_6(s) + 163O_2(g) \rightarrow 114\ CO_2(g) + 110H_2O(l) \qquad \Delta H = -75520\ kJ\ mol^{-1}$

i How many kilojoule of energy are available from one kilogram of fat?

ii On average a person will use 2420 kJ of energy during one hour's swimming.
Assuming all the energy required is supplied by the above reaction, determine the volume of CO_2 released at SLC during two hours of swimming.

(2 + 3 = 5 marks)

END of PAPER