MELBOURNE HIGH SCHOOL

UNIT 4 CHEMISTRY

Name: _____

TRIAL EXAMINATION

Group: _____

2009

Teacher: _____

QUESTION AND ANSWER BOOKLET

Wednesday 16th September 2009
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	57	67
		Total	77	90

Materials : * Question and answer booklet consisting of a cover page and 16 pages of questions - pages are numbered 2 to 17
* 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 / 57

Total / 77

4exam2009

2009 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 In an industrial process involving an equilibrium reaction, the conditions chosen to carry out the process will be those that will give

A. the most economical equilibrium yield and rate of reaction.
B. the best equilibrium yield.
C. the best rate of reaction.
D. both the best equilibrium yield and rate of reaction.

2 When a chemical reaction reaches equilibrium,

A. there are many possibilities for the concentrations of the species present at equilibrium.
B. the value of the equilibrium constant will only be changed by altering the pressure at constant temperature.
C. the rate of the reverse reaction will be greater than that of the forward reaction.
D. both the forward and reverse reactions cease to occur.

3 An industrial process that is used to produce hydrogen cyanide can be represented by the following chemical equation

$$2NH_3(g) + 2CH_4(g) + 3O_2(g) \rightleftharpoons 2HCN(g) + 6H_2O(g) \qquad \Delta H = -940 \text{ kJ mol}^{-1}$$

To improve the equilibrium yield of hydrogen cyanide a plant manager could

A. increase the pressure at which the process is carried out.
B. increase the temperature at which the process is carried out.
C. use a more efficient catalyst.
D. decrease the pressure at which the process is carried out.

4 The decomposition of sulfuryl dichloride can be represented by the chemical equation

$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g) \qquad \Delta H = +47 \text{ kJ mol}^{-1}$$

When 0.060 mol of sulfuryl dichloride was placed in a 2.0 L reaction vessel and allowed to decompose, the equilibrium concentration of chlorine in the gaseous mixture was 0.025 M. What is the value for the equilibrium constant for this reaction at the temperature the experiment was carried out?

A. 0.018 M
B. 0.13 M
C. 7.7 M
D. 0.0625 M

Questions 5 and 6 refer to the following information.

The reaction between water vapour and carbon monoxide can be represented by the chemical equation:

$$H_2O(g) + CO(g) \rightarrow H_2(g) + CO_2(g) \quad \Delta H = -41 \text{ kJ mol}^{-1}$$

The value of the concentration ratio of hydrogen gas to water vapour, $[H_2(g)]/[H_2O(g)]$, at equilibrium for a given set of conditions is 3.5.

5 For this system the activation energy, E_a, for the reverse reaction is

A. lower than the activation energy for the forward reaction.
B. the same as the activation energy for the forward reaction.
C. greater than the activation energy for the forward reaction.
D. 41 kJ mol^{-1}.

6 Compared with the set of conditions used, what effect would doubling the pressure and maintaining the same temperature have on the equilibrium concentration ratio of hydrogen gas to water vapour?

A. The value of the concentration ratio would double.
B. The value of the concentration ratio would be higher.
C. The value of the concentration ratio would be lower.
D. The value of the concentration ratio would be the same.

7 Sulfur trioxide is produced from sulfur dioxide thus:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -198 \text{ kJ mol}^{-1}$$

The equilibrium yield of sulfur trioxide will be high under conditions of

A. high temperature, high pressure and low concentration of SO_2.
B. low temperature, high pressure and excess air.
C. high temperature, low pressure and excess air.
D. low temperature, low pressure and excess SO_2.

8. Ammonia is synthesised by the direct combination of hydrogen and nitrogen, thus:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

In order to reduce the cost of producing ammonia, the rate of conversion should be as large as possible. Which one of the following factors alone would not increase the reaction rate?

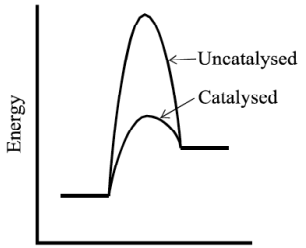
A. increasing the temperature of the gases in the reaction vessel
B. removal of the ammonia as soon as it is produced
C. addition of more hydrogen
D. inclusion of an efficient catalyst in the reaction vessel

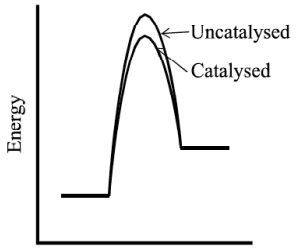
9. A diabetic person sometimes produces species that cause the blood pH to be lowered. The body automatically attempts to correct the pH. Part of this correction is achieved by an increase in the breathing rate to enable more carbon dioxide to be expelled from the lungs. The following reactions are involved:

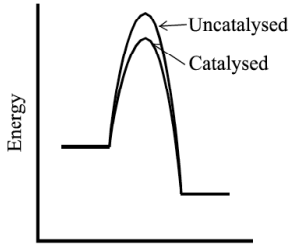
Reaction 1	$CO_2(g) \rightleftharpoons CO_2(aq)$
Reaction 2	$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$
Reaction 3	$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

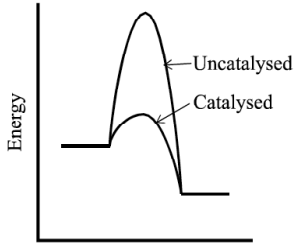
For the pH to be raised in this way, the equilibrium position for:
A. Reaction 3 only must shift to the left.
B. Reaction 3 only must shift to the right.
C. all reactions must shift to the left.
D. all reactions must shift to the right.

10 Which one of the following diagrams would best represent the energy profile for an endothermic reaction where the rate of reaction was significantly increased by the presence of a catalyst?

A.


B.


C.


D.


11. Which of the following reactions would be least likely to occur in a fossil fuel power station?

A. $C_8H_{18}(l) + 12½O_2(g) \rightarrow 8CO_2(g) + 9H_2O(g)$
B. $C(s) + O_2(g) \rightarrow CO_2(g)$
C. $H_2(g) + ½O_2(g) \rightarrow H_2O(g)$
D. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

12 300 mL of 2.50 M KOH is mixed with 500 mL of 1.20 M HCl.
56.0 kJ of energy is given off for each mol of KOH reacting.

The energy released in this reaction is

A. 8.40 kJ
B. 33.6 kJ
C. 56 kJ
D. 84.2 kJ

13. Methylated spirits is mostly ethanol but also contains a small amount of methanol and other toxic compounds. The most suitable unit for the heat of combustion of methylated sprits would be:

A. kJ mol^{-1} .
B. kJ L^{-1} .
C. kJ g^{-1} .
D. kJ .

14. Given that

$$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$$

then the reaction that is expected to occur when tin(II) nitrate solution is added to iron(II) nitrate solution is:

A. $Sn^{2+}(aq) + 2Fe^{2+}(aq) \rightarrow Sn(s) + 2Fe^{3+}(aq)$.
B. $Sn^{2+}(aq) + Fe^{2+}(aq) \rightarrow Sn^{4+} + Fe(s)$.
C. $Sn^{2+}(aq) + 2Fe^{3+}(aq) \rightarrow Sn^{4+}(aq) + 2Fe^{2+}(aq)$.
D. no reaction is expected to take place.

15 In an electrochemical cell such as the Daniell Cell, chemical energy is converted into electrical energy. The Daniell Cell is made up of $Cu(s)/CuSO_4(aq)$ and $Zn(s)/ZnSO_4(aq)$. When the cell is producing energy, the cathode is

A. the positive electrode and zinc metal is deposited
B. the negative electrode and zinc metal is deposited
C. the positive electrode and copper metal is deposited
D. the negative electrode and copper metal is deposited

16 An electrolytic cell is constructed using two nickel electrodes and an aqueous solution of nickel(II) sulfate as the electrolyte. When an electric current is passed through this cell

A. oxidation would be occurring at the negative electrode and the mass of this electrode would increase as the reaction proceeds.
B. reduction would be occurring at the positive electrode and the mass of this electrode would increase as the reaction proceeds.
C. oxidation would be occurring at the positive electrode and the mass of this electrode would decrease as the reaction proceeds.
D. reduction would be occurring at the negative electrode and the mass of this electrode would decrease as the reaction proceeds.

17 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. $2Na^+(aq) + 2Cl^-(aq) \rightarrow 2Na(s) + Cl_2(g)$

18. The overall reaction for a discharging Nicad cell is:

$$Cd(s) + 2NiOOH(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + 2Ni(OH)_2(s)$$

In a Nicad cell that is being recharged, the anode reaction is:

A. $Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$
B. $Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$
C. $NiOOH(s) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$
D. $Ni(OH)_2(s) + OH^-(aq) \rightarrow NiOOH(s) + H_2O(l) + e^-$

19. When a lead/acid accumulator is discharging, the reaction is

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

When the lead/acid accumulator is being charged,

A. lead plates act as the anodes.
B. the pH of the electrolyte increases.
C. the conductivity of the electrolyte decreases.
D. lead (IV) oxide is being produced.

20. The products of the electrolysis of molten potassium fluoride are:

A. hydrogen and oxygen.
B. hydrogen and fluorine.
C. oxygen and fluorine.
D. potassium and fluorine.

End of Section A

2009 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.
- ***57*** marks, 67 minutes

1 [7 marks, 9 minutes]
Ammonia can be produced according to the equation below:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

In one experiment conducted at 400°C, the concentrations of all three gases in the system were determined. The results are shown in the table below:

	Gas Concentration (mol L^{-1})
N_2	0.30
H_2	0.40
NH_3	0.40

a) Write an expression for the equilibrium constant, K, for this reaction.

(1 mark)

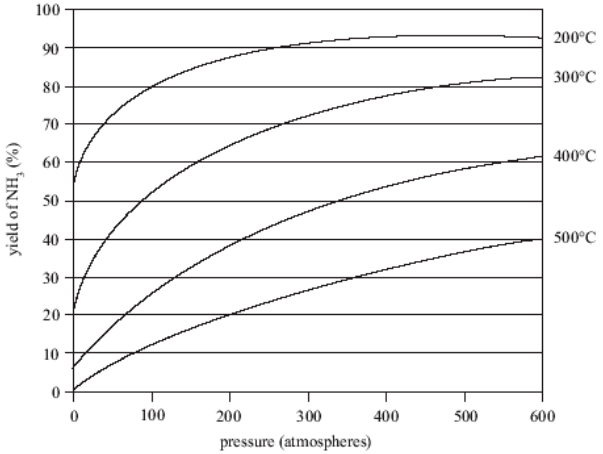
The value of K for this reaction at 400°C is 0.50 M^{-2}.

b) Using your K expression from a), explain why the system above is not at equilibrium.

(2 marks)

Question 1 continued……

The yield of ammonia produced is affected by different reaction conditions, as shown in the graph below:



c) i. Deduce, with reference to the graph, whether the reaction that is producing ammonia is exothermic or endothermic.

(1 mark)

ii. Explain, in terms of Le Châtelier's principle, why increasing the pressure produces a higher yield of ammonia.

(3 marks)

2 [4 marks, 4 minutes]
A chemist calibrated a bomb calorimeter, then used it to determine the amount of energy released from a 2.036 g sample of brown coal. The data collected for the electrical calibration and the combustion reaction are shown below.

Initial Temperature	21.362 °C
Voltage	5.63 V
Current	4.52 A
Time	10.00 minutes
Temperature after calibration	21.866 °C
Temperature after combustion	23.819 °C

a) Use the data to calculate the calibration factor for the calorimeter.

(2 marks)

b) Use the data to determine the energy available from 1.00 kg of brown coal, expressed as kJ kg^{-1}.

(2 marks)

3 [4 marks, 5 minutes]
Propanoic acid (propionic acid), CH_3CH_2COOH, is a weak acid.

a) Write the equation for the hydrolysis of propanoic acid.

(1 mark)

b) What is the pH of a 0.0150 M propanoic acid solution? *Give your answer correct to 1 decimal place.*

(3 marks)

work space

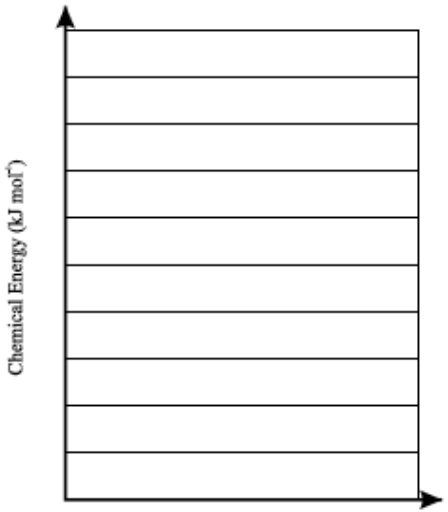
4 [12 marks, 14 minutes]

a) The chemical potential energies for the reactants and products of a chemical reaction are -420 kJ mol^{-1} and -560 kJ mol^{-1} respectively. The activation energy for the reverse reaction is 900 kJ mol^{-1}.

i. On **Grid 1** draw the energy profile for this reaction clearly marking all of the appropriate energies and the ΔH for the reaction.

ii.

Grid 1



(3 marks)

ii. Determine the enthalpy change, ΔH, for this reaction.

(1 mark)

iii. Determine the activation energy for the forward reaction.

(1 mark)

Question 4 continued……

b) Methanol can be oxidised to either methanal or methanoic acid by oxygen gas as described by the chemical equations

$CH_3OH(g) + ½ O_2(g) \rightarrow HCHO(g) + H_2O(l)$ $\Delta H = -194$ kJ mol^{-1}

$CH_3OH(g) + O_2(g) \rightarrow HCOOH(g) + H_2O(l)$ $\Delta H = -464$ kJ mol^{-1}

i. Write an appropriate chemical equation for the oxidation of methanal to methanoic acid by oxygen.

(1 mark)

ii. Determine the enthalpy change for the oxidation of methanal to methanoic acid by oxygen.

(1 mark)

c) Use collision theory to explain the following observations regarding the rate of chemical reactions.

i. If the temperature is lowered then the rate of the reaction will decrease.

(2 marks)

ii. When zinc powder is added to an aqueous solution of copper(II) sulfate the blue colour due to the copper(II) ions fades significantly faster than when a similar mass of zinc strips are added.

(1 mark)

iii. When a catalyst is added to a reaction the rate of the reaction will increase compared to the rate of an uncatalysed reaction at the same temperature.

(2 marks)

5 [10 marks, 11 minutes]
Two of the biofuels that are currently being produced and used for transportation fuels are bioethanol and biodiesel.

a) The production of these biofuels requires the use of energy, in addition to solar energy, to produce the fuel.

Other than solar energy, what are ways that each of these biofuels can be produced?

(2 marks)

b) i. Write an appropriate chemical equation for the complete combustion of bioethanol?

(1 mark)

ii. How does the energy released by 1.00 g of ethanol compare with the energy released by a similar mass of petrol assuming it is composed of octane?

(3 marks)

c) Many people see these two biofuels as a viable alternative to supplement or replace the large amounts of fossil fuels used for transportation.

i. What is one advantage of using a biofuel for this purpose?

(1 mark)

ii. What is one disadvantage of using a biofuel for this purpose?

(1 mark)

d) At present methane gas produced at some landfill and sewage treatment plants is being used to produce electricity on site.

i. Why could methane produced in this manner be considered as a biofuel?

(1 mark)

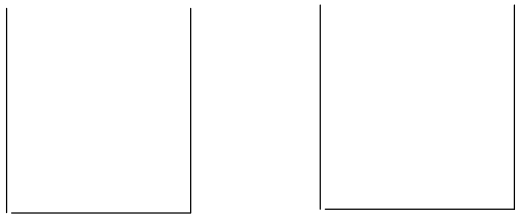
ii. What is one advantage of using methane produced in this manner instead of using methane from natural gas to generate electricity at the plant?

(1 mark)

6 [10 marks, 12 minutes]
A simple galvanic cell is composed of a standard nickel half-cell coupled with a standard half-cell of your choice. The cell meets the following requirements:
- the nickel half-cell is the anode
- the cell emf is at least 1.00 V
- gases do not participate in the cell reaction

a) Sketch this cell (including the external circuit), clearly identifying:
- the solutions used (including their concentrations)
- the solids used as the electrodes
- the direction of electron flow in the external circuit
- the polarity of the half-cells

(Cell diagram)



(4 marks)

b) Give the half and overall equations for the cell reaction.

Cathode: _____

Anode: _____

Overall: _____

(3 marks)

c) The salt bridge usually involves a solution of an ionic compound.
i. Name an ionic compound that would be suitable for use in the salt bridge of your cell.

_____

(1 mark)

Question 6c continued……

ii. Use your half equations in b) above to help explain the direction of flow of the ions out of the salt bridge.

_____

_____

_____

_____

_____

_____

(2 marks)

7 [5 marks, 5 minutes]
The equation below gives the standard electrode potential of a reaction not supplied in the data Table. This information may be useful when answering this question.

$2HCOO^-(aq) + 2CO_2(g) + 6H^+(aq) + 6e^- \rightleftharpoons C_4H_4O_6^{2-}(aq) + 2H_2O(l)$ $\quad E^o = +0.20$ V

Hydrogen peroxide can act as either an oxidant or as a reductant.

a) Hydrogen peroxide is added to an acid solution containing both $HCOO^-$ and $C_4H_4O_6^{2-}$ ions under standard conditions. Write the half and overall equations for the reaction expected to occur between H_2O_2 and these species.

Oxidation: _____

Reduction: _____

Overall: _____

(3 marks)

b) When hydrogen peroxide acts as both the oxidant and the reductant (*ie* it reacts with itself) it is said to have undergone disproportionation. Write the overall equation for the disproportionation of hydrogen peroxide.

_____

(1 mark)

c) Given that hydrogen peroxide reacts with itself, why is it possible to store solutions of hydrogen peroxide for extended periods of time provided it is kept in the dark?

_____

_____

_____

(1 mark)

8 [2 marks, 3 minutes]
Both fuel cells and secondary galvanic cells convert chemical potential energy into electrical energy. Why, then, are fuel cells known as energy converters whereas secondary cells are referred to as energy storers? Include an example of each type of cell in your answer.

(2 marks)

9. [3 marks, 4 minutes]
A simplified equation for the electrolytic production of aluminium is

$$2Al_2O_3(l) + 3C(s) \rightarrow 4Al(l) + 3CO_2(g)\ .$$

a) Write the half equation for the anode process.

(1 mark)

b) Why is the energy-expensive electrolysis of molten alumina used for aluminium production rather than the less energy-expensive electrolysis of a concentrated aqueous solution of an aluminium salt such as $AlCl_3$?

(2 marks)

END of PAPER

Xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Extra Section A Questions

LisaChem 08 AoS

Question 7

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. $2Na^+(aq) + 2Cl^-(aq) \rightarrow 2Na(s) + Cl_2(g)$

Kilbaha 2007 Unit 4

Insight 2006
Q8
The self-ionisation constant of pure water at 55°C is 7.29 x 10-14M2. The hydroxide ion concentration and pH will be respectively,
A 1.0 x 10-7M and 6.57
B 1.0 x 10-7M and 7.00
C 2.7 x 10-7M and 6.57
D 2.7 x 10-7M and 7.00

2001 unit 4 trial

2. 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.

2001 unit 4 trial
4. Consider the reaction
$$HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq) \qquad \Delta H = -57.0 \text{ kJ mol}^{-1}$$
When 20.0 mL of 0.150 M NaOH is reacted with 10.0 mL of 0.250 M HCl, the amount of heat released is:
A. 28.5 J.
B. 143 J.
C. 171 J.
D. 314 J.

2001 unit 4 trial

7. The E° for the half cell $Q^{2+}(aq)/Q^+(aq)$ is +0.50 V and the E° 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.

2001 unit 4 trial

10. 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.

Question 3

The following reaction was allowed to reach equilibrium $A + B \rightleftharpoons xC$.
When the system is at equilibrium, the concentrations of A, B, and C are given by c(A) = 0.5 M , c(B) = 0.4 M, c(C) = 0.5 M. The value of K is 0.156 for the given temperature of this experiment. The value of *x* is

A. 5

B. 4

C. 3

D. 2

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx Rates – 1 1

1 LisaChem 08 AoS Q6
2 2001 unit 3 trial Q 11
3 LisaChem 08 AoS **Question 3**
4 LisaChem 08 AoS **Question 4**
5, 6 LisaChem 08 AoS ??? or **Learning Materials *by Lisachem*** VCE Chemistry 2008 Year 12 Unit 4 – Industrial Chemistry 2 - *Questions 11 and 12*
7 2001 unit 3 trial Q12
8 2001 unit 3 trial Q12 or 13
9 2001 unit 3 trial Q14
10 LisaChem 08 AoS **Question 5**
11 2001 unit 4 trial Q 1
12 Kilbaha 4 2007 **Question 2**
13 2001 unit 4 trial Q3
14 2001 unit 4 trial Q 5
15 Kilbaha 2007 Unit 4 **Question 3**
16 LisaChem 08 AoS **Question 4**
17 LisaChem 08 AoS **Question 7**
18 2001 unit 4 trial Q6
19 2001 unit 4 trial Q8
20 2001 unit 4 trial Q9

Xxxxxxxxxxxxxxx

Xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Extra Section B questions

2001 4 Trial exam

1. [5 marks, 8 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.

LisaChem Aos 2008 Unit 4

Question 4 (7 marks, 8 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. 122$4A(g)5O(g)4B(g)6HO(g)H907kJmol-+\rightarrow+\Delta=-$
2. 12$2B(g)O(g)2D(g)H114kJmol-+\Delta$
3. 123$D(g)HO(l)2E(aq)B(g)H137kJmol-+\rightarrow+\Delta=-$

a. Why would a catalyst be used in the first stage of this process?
(1 mark)

b. The gases exiting the first stage of the process are at about 900 ¼C. These are cooled to about 50 ¼C and mixed with air (oxygen) before being compressed. Explain how these changes would effect the equilibrium yield of the second stage.
(2 marks)

c. How would the plant deal with any waste gases produced in the third stage of the process?
(1 mark)

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?

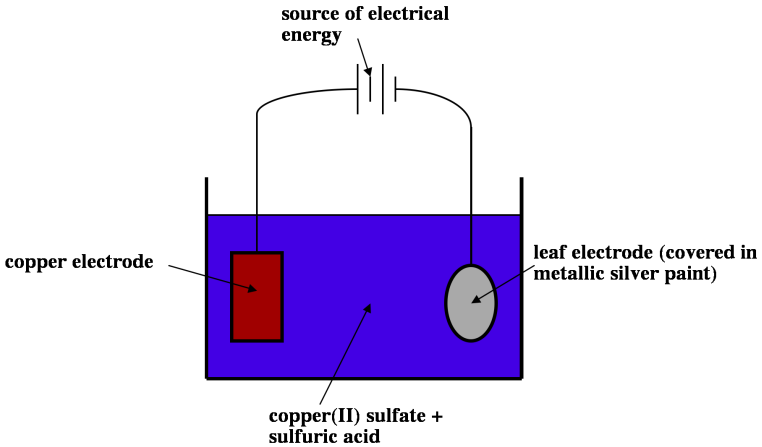
(1 mark)

e. What are two possible health and safety issues that could be associated with an industrial chemical process such as the one described?

(2 marks)

Kilbaha 2007 Unit 4
Or

Question 2
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.

_____

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Section B

Question 2 (continued)

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

_____

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_____

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_____

1+1+1+2+2 = 7 marks

5 Kilbaha 2007 Unit 4 **Question 3**
5 [6 marks, 6 minutes]
When hydrochloric acid and sodium hydroxide are mixed an exothermic reaction occurs.

In one experiment, 400 mL of 0.20M HCl(aq) was mixed with 400 mL of 0.20M NaOH(aq) in a calorimeter and the energy released was measured as 4.56 kJ.

a. Calculate the energy that would be released when 400 mL of 0.20M HCl is mixed with 600 mL of 0.20M NaOH. Show your working.

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b. Write a balanced ionic equation for this reaction and calculate the ΔH value.

c. Calculate the temperature rise that would occur in **a.**

2+2+2 = 6 marks

Question 9

A metal plate of total surface area 20 cm^2 is to be covered **all over** with a coating of silver 0.200 mm thick. The coating is to be applied by electrolysis with the disc forming the cathode (negative electrode) of an electrolysis cell. The plate is suspended by a conducting wire into a large volume of an aqueous solution containing the ions $K^+(aq)$ and $Ag(CN)_2^-(aq)$.

The $Ag(CN)_2^-(aq)$ ion is reduced at the cathode (negative) electrode according to the equation:

$Ag(CN)_2^-(aq) + e^- = Ag(s) + 2CN^-(aq)$.

Calculate the time needed to deposit a coating of 0.200 mm if a steady current of 1.000 A is passed through the cell. The density of silver is 10.5 g cm^{-3}.

4 marks

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SECTION B
1 Item Bank – Rates of reaction and equilibrium Q 10
2 **Learning Materials *by Lisachem*** VCE Chemistry 2008 Year 12 Unit 4 – Supply & Using Energy 7
3 2001 Unit 3
4 LisaChem Aos 1 Q3
5 AoS2 Lisachem B Q 1
6 2001 4 Trial exam
7 2001 4 Trial exam
8 2001 4 Trial exam Q4?
9 2001 4 Trial exam Q5?

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1 [9 marks - 12 minutes] 10
2 [4 marks, 4 minutes] 4
3. [4 marks, 5 minutes] 4
4 [10 marks, 12 minutes] 11 27
5 [11 marks, 11 minutes] 11 39
6. [10 marks, 11 minutes] 11 49
7. [5 marks, 7 minutes] 5 54
8. [2 marks, 3 minutes] 3 56
9. [7 marks, 9 minutes] 7 63

67

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ANSWESR
1 **Question 10 solution**

a) $K = \frac{[NH_3]^2}{[H_2]^3 \times [N_2]}$ ❶

b) $K = \frac{[0.4]^2}{[0.4]^3 \times [0.3]} = \mathbf{8.3\ M^{-2}}$ ❶

K is > than 0.5 ❶ => the system is **not** at equilibrium. ❶

c) i) As the temperature increases the yield of ammonia decreases. ❶
The reaction must be exothermic. ❶

ii) If you increase the pressure, according to Le Chatelier's principle the system will shift so as to partially oppose this change. ❶ The reaction will shift to try and lower the pressure❶ and move to the side with fewer particles, in this reaction the products side and the yield of ammonia increases.❶

2 b. i. The calibration factor for a calorimeter is the amount of energy required to change the temperature of the calorimeter and its contents by 1 ºC.
The time, t, used in the calculations must be in seconds
Energy = V × I × t = 5.63 × 4.52 × 10.00 × 60 = 1.53 x 10_4 J **(1 mark)**
ΔT = 21.866 – 21.362 = 0.504 ºC
CF = E / ΔT = 1.53 × 10_4 / 0.504 = **3.04 • 10_4 J ºC$_{-1}$ (1 mark)**
ii. For the combustion of the brown coal.
ΔT = 23.819 – 21.866 = 1.953 ºC
E = CF × ΔT = 3.04 × 10_4 × 1.953 = 5.94 × 10_4 J = 59.4 kJ **(1 mark)**
This energy is released by 2.036 g of coal therefore from 1.00 kg (1000 g)
E = (59.4 / 2.036) × 1000 = **2.92 • 10_4 kJ kg$_{-1}$ (1 mark)**

3
6. a/ $CH_3CH_2COOH(aq) + H_2O(l) \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq)$
b/ $K_a = [CH_3CH_2COO^-][H_3O^+] \div [CH_3CH_2COOH]$ At eqbm, $[CH_3CH_2COO^-] = [H_3O^+] = x$ M
and,
since propanoic acid is a weak acid, very little of it is hydrolysed so we assume that the concentration of propanoic acid is still 0.150 M (the weak acid assumption)
$\therefore x^2 = K_a \times [CH_3CH_2COOH] = 1.35 \times 10^{-5} \times 0.0150$
$\therefore x = [H_3O^+] = \sqrt{(1.35 \times 10^{-5} \times 0.0150)}$ M
$\therefore$ pH= $-\log_{10}(\sqrt{(1.35 \times 10^{-5} \times 0.0150)})$ = **3.3** [1 + 3 = **4**]

4
Question 2 (11 marks, 12 minutes)
a. i. The energies for the reactants and products must be shown as -420 and -560 kJ mol$_{-1}$ respectively. **(1 mark)**
The activation energy position must be shown
-560 + 900 = **+340 kJ mol$_{-1}$. (1 mark)**
The ΔH must be shown as the energy difference between the reactants and products. **(1 mark)**

graph

ii. The enthalpy change is the difference between the chemical potential energy of the products and reactants.
ΔH = E(products) – E(reactants) = -560 – (-420) = **-140 kJ mol$_{-1}$. (1 mark)**
iii. The activation energy for the forward reaction is,
E_a(forward) = 340 – (-420) = **760 kJ mol$_{-1}$. (1 mark)**
b. i. Methanal, HCHO, being oxidised to methanoic acid, HCOOH.
$_2$1HCHO(g)O(g)HCOOH(g)2+ **(1 mark)**
ii. ΔH = -464 – (-194) = **-270 kJ mol$_{-1}$. (1 mark)**
c. i. Lowering the temperature **lowers the average kinetic energy** of the particles, therefore **less particles will have sufficient energy for a fruitful collision** thereby lowering the rate of reaction. In addition the lower average kinetic energy will result in the particles travelling more slowly therefore there will also be a **less likelihood of a collision occurring** between the particles also contributing to a lower rate of reaction. **(1 mark)**
ii. The zinc powder **has a higher surface area** therefore there will be **mores sites available for a fruitful reaction to occur at** increasing the rate of reaction. **(1 mark)**
iii. In the dilute acid there will be **less particles present in a given volume** therefore there will be a **lower chance of fruitful collisions between the particles**, lowering the rate of reaction. **(1 mark)**

iii. A catalyst **provides an alternative reaction pathway with a lower activation energy**, therefore at a given temperature in the presence of a catalyst, **more particles will have sufficient energy for a fruitful collision to occur. (1 mark)**

5

Question 3 (10 marks, 11 minutes)
a. i. M(C_8H_{18}) = 8•12.0 + 18• 1.0 = 114.0 g mol$_{-1}$
1.00 kg = 1000 g
n(C_8H_{18}) = m / n = 1000 / 114.0 = 8.77 mol **(1 mark)**
From Table 13 the molar enthalpy of combustion for octane is -5464 kJ mol$_{-1}$
Therefore 1 mol of octane will release 5464 kJ of energy when burnt.
E = n • 5464 = 8.77 • 5464 = **4.79•10_4 kJ (1 mark)**
ii. Each mol of octane burnt will result in the formation of 8 mol of CO_2
n(CO_2) = 8 • n(C_8H_{18}) = 8 • 8.77 = **70.2 mol (1 mark)**
iii. M(C_2H_5OH) = 2•12.0 + 6•1.0 + 16.0 = 46.0 g mol$_{-1}$
From Table 13 the molar enthalpy of combustion for ethanol is -1364 kJ mol$_{-1}$
Therefore 1 mol of ethanol will release 1364 kJ of energy when burnt.
The blend contains 10.0 % ethanol by mass, therefore 1.00 kg of fuel contains:
m(C_2H_5OH) = 100 g
m(C_8H_{18}) = 900 g
n(C_2H_5OH) = m / M = 100 / 46.0 = 2.17 mol
E(from ethanol) = 2.17 • 1364 = 2.96•10_3 kJ **(1 mark)**
n(C_8H_{18}) = 900 / 114.0 = 7.89 mol
E(from octane) = 7.89 • 5464 = 4.31•10_4 kJ
E(Total) = 2.96•10_3 + 4.31•10_4 = **4.61•10_4 kJ (1 mark)**
iv. Each mol of ethanol burnt will result in the formation of 2 mol of CO_2
n(CO_2, total) = 8•n(C_8H_{18}) + 2•n(C_2H_5OH) **(1 mark)**
n(CO_2, total) = 8•7.89 + 2•2.17 = **67.4 mol (1 mark)**
v. Since the blended fuel releases less energy then the amount of carbon dioxide released, to obtain the same amount of energy will be given by
n(CO_2) = $_{28}$n(CO,blendedfuel)E(CH)E(blendedfuel) ×
n(CO_2) = $_{44}$67.44.79104.6110×××= **70.0 mol (1 mark)**
b. i. Possible answers could include: **(1 mark)**
The blended fuel contains bioethanol which is a renewable resource.

The use of bioethanol will reduce the demand on the limited fossil fuel reserves of crude oil.
The bioethanol can be produced locally and therefore reduces imports of crude oil.
Growing the feedstock for bioethanol production will mean that the carbon dioxide emitted by the ethanol will be removed from the atmosphere.

ii. Possible answers could include: **(1 mark)**
The use of food crops to produce bioethanol has increased the price of many staple foods.
Biofuel production is currently receiving large government subsidies.
Land for growing biofuels is resulting in deforestation.
Land being used to grow biofuels is lowering the amount of land available for growing food crops.
Water resources are being taken away from growing food crops to produce biofuel crops.

6

2. a/ • $Ni^{2+}(aq)/Ni(s)$ standard half cell coupled with any non-gas standard half cell with $E^o \geq +0.77$ V (including the one from Q3)

• *for example*:

Cell must show the following:
• solutions and their concentrations
• solids used as the electrodes
• direction of e^- flow in external circuit
• polarity of the half cells

b/ For example:

• *half equations: ½ mark only if all species are correct but the half equation is unbalanced.*
• *overall equation: 1 mark if incorrect but it is a correct addition of the half equations, provided that the half equations contain electrons.*

$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$
$(Ag^+(aq) + e^- \rightarrow Ag(s)) \times 2$
$Ni(s) + 2\ Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$

c/ i. ammonium nitrate, sodium nitrate, potassium nitrate, etc. [Don't accept acids, hydroxides, halides, etc.]

ii. Assuming KNO_3: the formation of extra +ve ions (Ni^{2+}) at the anode is counterbalanced by the nitrate ions flowing out of the salt bridge into the anode solution; the potassium ions flow from the salt bridge into the cathode electrolyte replacing the +ve ions (Ag^+) that are reduced (or equivalent, depending on choice of cathode half cell) [(2 + 4 × ½) + 3 + (1 + 2) = **10**]

7

3. a/ $C_4H_4O_6^{2-}(aq) + 2H_2O(l) \rightarrow 2HCOO^-(aq) + 2CO_2(g) + 6H^+(aq) + 6e^-$
$(H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)) \times 3$
$C_4H_4O_6^{2-}(aq) + 3H_2O_2(aq) \rightarrow 2HCOO^-(aq) + 2CO_2(g) + 4H_2O(l)$

b/ $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

c/ Rate of disproportionation is very low when hydrogen peroxide is kept in the dark - light supplies the activation energy for the decomposition. [3 + 1 + 1 = **5**]

8

4. Secondary cells (*eg* Nicad cell, lead/acid accumulator) have a finite amount of reactants which, when used, have to be regenerated (*ie* by recharging the cell) - hence secondary cells store a limited amount of electrical energy as chemical energy. Fuel cells (*eg* hydrogen/oxygen or methane/oxygen fuel cell) can convert chemical energy continuously into electrical energy provided they are continually supplied with the fuel and the oxidant.
[1 + 2 × ½ = **2**]

9

5. a/ $C(s) + 2O^{2-}(l) \rightarrow CO_2(g) + 4e^-$ (care with states!)

b/ $Al^{3+}(aq)$ ions are a weaker oxidant than water and $Cl^-(aq)$ ions are a weaker reductant that water. Thus, less energy required to reduce the water than the Al^{3+} ions and to oxidise the water than the Cl^- ions. Hence, if an aqueous solution were used, the water would be electrolysed preferentially and no aluminium would be produced.

c/ $Al^{3+}(l) + 3e^- \rightarrow Al(l)$
$n(Al) = (1.000 \times 10^6) \div 27.0$ mol
$\therefore n(e^-) = (3 \times 1.000 \times 10^6) \div 27.0$ mol
$\therefore Q = (3 \times 1.000 \times 10^6 \times 9.65 \times 10^4) \div 27.0$ C
$\therefore t = (3 \times 1.000 \times 10^6 \times 9.65 \times 10^4) \div (27.0 \times 175.0 \times 10^3)$ s
$= (3 \times 1.000 \times 10^6 \times 9.65 \times 10^4) \div (27.0 \times 175.0 \times 10^3 \times 3600) =$ **17.0 h** [1 + 2 + 4 = **7**]