# VCE CHEMISTRY 2009

## YEAR 12 TRIAL EXAM UNIT 4



**Time allowed: 90 minutes**
**Total marks: 82**

20 Multiple Choice Questions
6 Short Answer Questions

**An Answer Sheet is provided for Section A.**
**Answer all questions in Section B in the space provided.**

**To download the Chemistry Data Book please visit the VCAA website:**
http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf *Page 20*

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## Student Name.....…….....……

# VCE Chemistry 2009 Year 12 Trial Exam Unit 4

## Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake erase and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are 20 Multiple Choice questions to be answered by circling the correct letter in the table below.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Question 1* | A | B | C | D | *Question 2* | A | B | C | D |
| *Question 3* | A | B | C | D | *Question 4* | A | B | C | D |
| *Question 5* | A | B | C | D | *Question 6* | A | B | C | D |
| *Question 7* | A | B | C | D | *Question 8* | A | B | C | D |
| *Question 9* | A | B | C | D | *Question 10* | A | B | C | D |
| *Question 11* | A | B | C | D | *Question 12* | A | B | C | D |
| *Question 13* | A | B | C | D | *Question 14* | A | B | C | D |
| *Question 15* | A | B | C | D | *Question 16* | A | B | C | D |
| *Question 17* | A | B | C | D | *Question 18* | A | B | C | D |
| *Question 19* | A | B | C | D | *Question 20* | A | B | C | D |

# VCE Chemistry 2009 Year 12 Trial Exam Unit 4

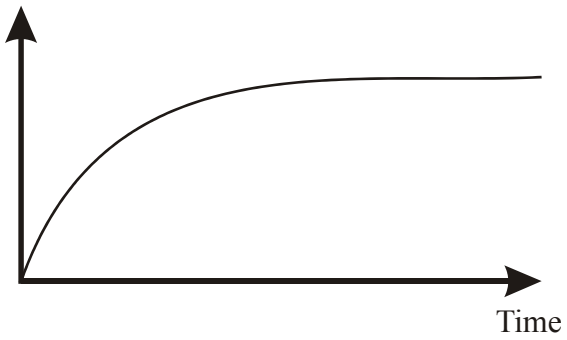
## Multiple Choice Questions – Section A

*Section A consists of 20 multiple-choice questions.*
*Section A is worth approximately 25 per cent of the marks available.*
*Choose the response that is **correct** or **best answers** the question.*
*Indicate your choice on the answer sheet provided.*

**Question 1**
The reaction between zinc and hydrochloric acid may be represented by the equation

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g); \Delta H = -154 \text{ kJ mol}^{-1}$$

In an investigation of this reaction using excess Zn and 2 M HCl(aq) in an open flask, the following graph was plotted from data collected.



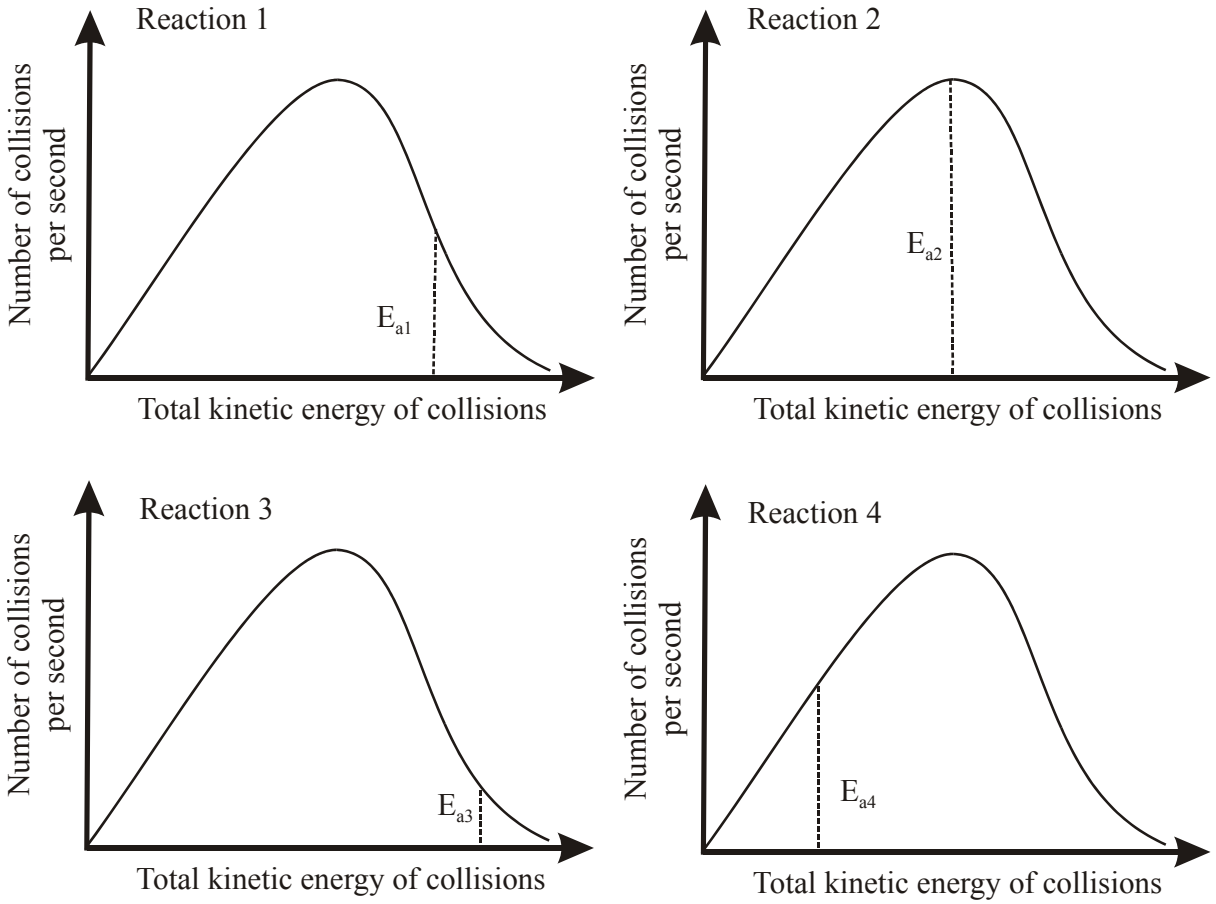

Which of the following would be a suitable quantity for the vertical axis of the graph?
A. Number of collisions per second.
B. Rate of reaction.
C. Temperature.
D. Number of ions.

**Question 2**
Zinc-air batteries used in hearing aids and experimental electrical vehicles have high energy density and are relatively inexpensive to produce.
The overall redox reaction for a zinc-air battery delivering electrical energy may be described by the equation

$$2Zn(s) + O_2(g) + 2H_2O(l) \rightarrow 2Zn(OH)_2(s)$$

In this battery, zinc, Zn
A. forms the positive electrode, and is reduced.
B. forms the positive electrode, and is oxidised.
C. forms the negative electrode, and is reduced.
D. forms the negative electrode, and is oxidised.

**Question 3**
Shown below are kinetic energy distribution curves for four different reactions, all occurring at the same temperature.
The activation energies of the four reactions are represented by the symbols $E_{a1}$, $E_{a2}$, $E_{a3}$ and $E_{a4}$ respectively.




Which reaction is most likely to have the fastest reaction rate?
A. Reaction 1.
B. Reaction 2.
C. Reaction 3.
D. Reaction 4.

**Question 4**
The use of E10 fuel in car engines produces carbon dioxide due to the combustion of octane and ethanol according to the equations

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$$

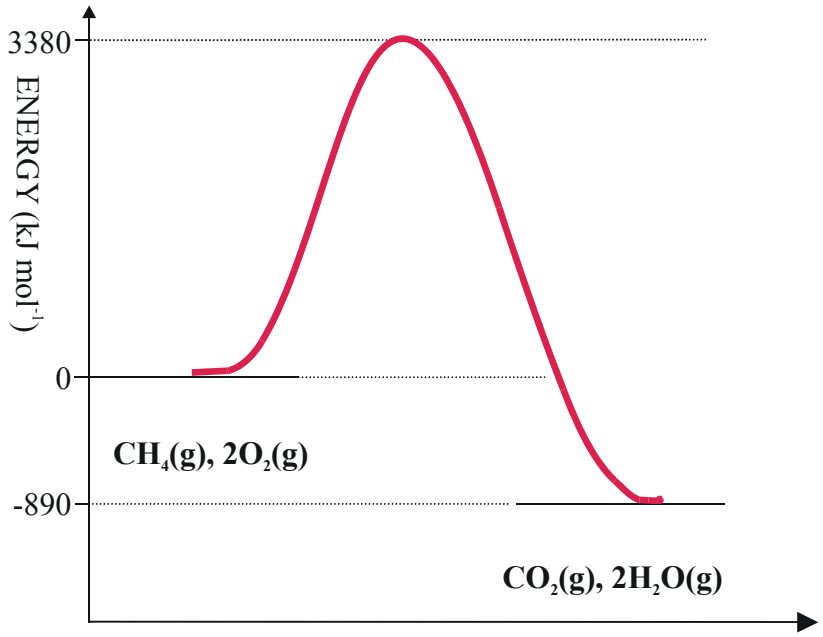
$$C_2H_6O(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

In a comparison of the complete combustion of samples of pure octane and pure ethanol, both samples release 2000 kJ of energy.
The ratio $n(CO_2)$ produced by octane sample : $n(CO_2)$ produced by ethanol sample is closest to

A. 1 : 1
B. 1 : 4
C. 4 : 1
D. 8 : 1

**Question 5**
Shown below is the energy profile for combustion of methane according to:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$



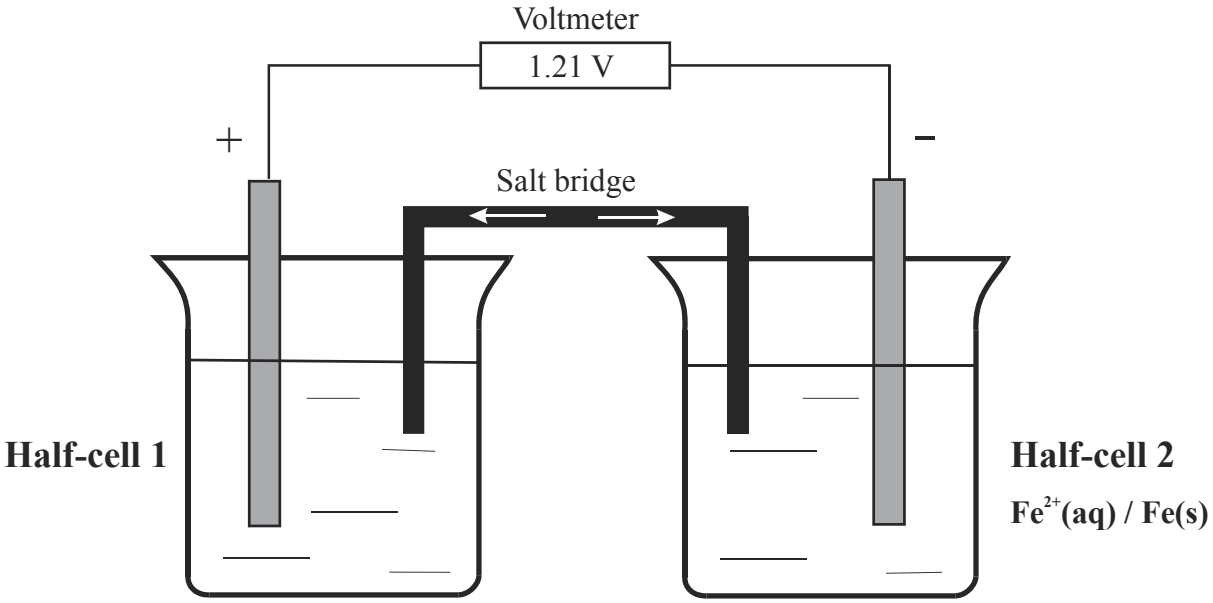

According to the information provided on this profile, the activation energy for the reaction

$$½CO_2(g) + H_2O(g) \rightarrow ½CH_4(g) + O_2(g)$$

would be

A. 1635 Kj.
B. 2135 kJ.
C. 2490 kJ.
D. 4270 kJ.

**Question 6**
Consider the galvanic cell represented below




Which of the following sets of species would most likely be present in Half-cell 1?
A. $O_2(g)$, $H^+(aq)$, $H_2O(l)$, Pt.
B. $Al^{3+}(aq)$, Al(s).
C. $Fe^{3+}(aq)$, $Fe^{2+}(aq)$, Pt.
D. $H^+(aq)$, $H_2(g)$, Pt.

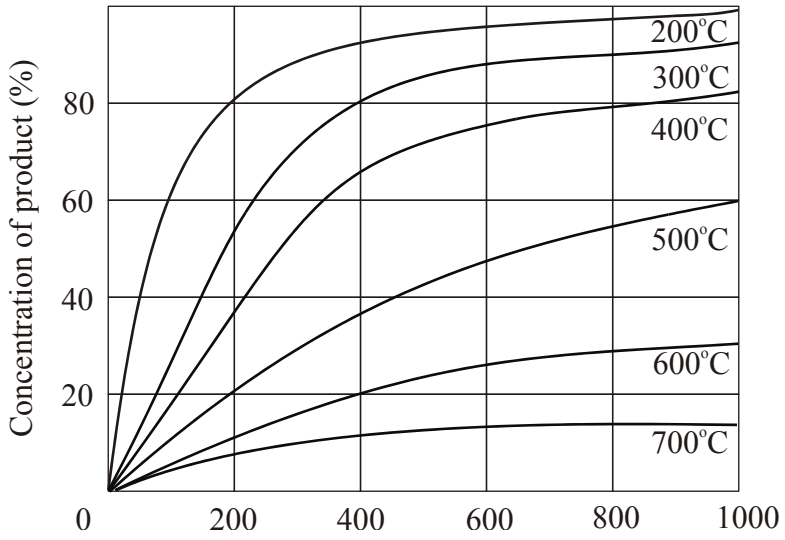
**Question 7**
At high temperature nitrogen and oxygen can react to produce nitrogen(II) oxide, NO.
All three species can exist in equilibrium as described by the equation

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

At 2300 K the equilibrium constant, $K_c$, for this equilibrium is $1.7 \times 10^{-3}$.
In a sealed rigid container at 2300 K, the concentration of $N_2$ is 0.50 mol $L^{-1}$, the concentration of $O_2$ is 0.25 mol $L^{-1}$ and the concentration of NO is $4.2 \times 10^{-3}$ mol $L^{-1}$.
Which of the following statements about this mixture is correct?
A. The rates of the forward and reverse reactions are equal.
B. The forward reaction is proceeding slower than the reverse reaction.
C. The forward reaction is proceeding faster than the reverse reaction.
D. The pressure in the container is increasing.

**Question 8**
When a current of 1.40 A was passed through the electric heater of a bomb calorimeter for 54.5 seconds at a potential difference 6.00 volts, the temperature of the calorimeter rose by 0.390°C.
When $9.50 \times 10^{-4}$ mol of a gaseous hydrocarbon gas underwent combustion in the calorimeter, the temperature rose from 21.45 to 22.17°C.
The hydrocarbon used was
A. butane.
B. ethane.
C. propane.
D. methane.

**Question 9**
Temperature and pressure are key factors in the production of common chemicals via equilibrium reactions. The data below show the relationships between percentage yield of product, temperature and pressure for the industrial production of a particular chemical.




According to these data,
A. the forward reaction is exothermic, and the product is on the side with fewer particles.
B. the forward reaction is endothermic, and the product is on the side with more particles.
C. the forward reaction is exothermic, and the product is on the side with more particles.
D. the forward reaction is endothermic, and the product is on the side with fewer particles.

**Question 10**
The half-equation for the reaction occurring at the negative electrode, during the production of fluorine by electrolysis of a fluoride salt, could be
A. $2F^-(aq) \rightarrow F_2(g) + 2e^-$
B. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
C. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
D. $K^+(l) + e^- \rightarrow K(l)$

**Question 11**
Ammonia is a weak base, which ionises in water according to the equation

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

If 20 mL of 0.10 M $NH_3(aq)$ is added to 50 mL of water, which of the following correctly describes the expected change in pH and number of ammonium ions present as a result of the dilution?

A. pH decreases, $N(NH_4^+)$ increases.
B. pH decreases, $N(NH_4^+)$ decreases.
C. pH increases, $N(NH_4^+)$ increases.
D. pH increases, $N(NH_4^+)$ decreases.

**Question 12**
Hydrogen reacts with oxygen to form water according to the thermochemical equation

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l); \quad \Delta H = -286 \text{ kJ mol}^{-1}$$

Hence $\Delta H$ for the equation
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
is most likely to be

A. +572 kJ $mol^{-1}$
B. -572 kJ $mol^{-1}$
C. -484 kJ $mol^{-1}$
D. +484 kJ $mol^{-1}$

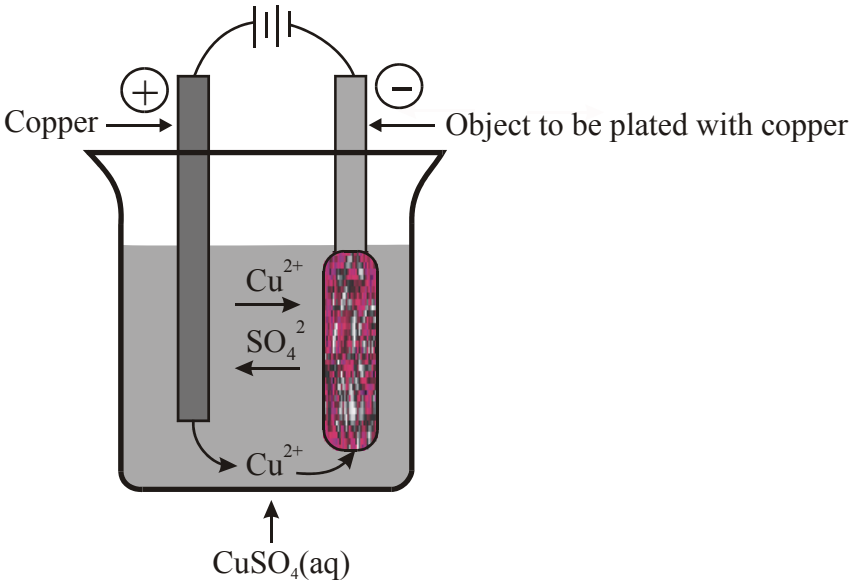
**Question 13**
When $SO_2(g)$ reacts with $O_2(g)$ to produce $SO_3(g)$, equilibrium is established, according to

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

At 1200 K, the equilibrium constant is 0.11 $M^{-1}$
For the equilibrium $SO_3(g) \rightleftharpoons SO_2(g) + \tfrac{1}{2}O_2(g)$ at 1200 K, the numerical value of the equilibrium constant will be

A. 0.33
B. 3.0
C. 9.0
D. $1.2 \times 10^2$

**Question 14**
An electrolytic cell used to electroplate objects with copper is represented below.




At regular intervals the (+) copper electrode is replaced with a new copper electrode. If the (+) copper electrode was mistakenly replaced with a carbon (graphite) electrode,
A. the pH of the solution would decrease.
B. bubbles of gas would immediately appear at the (-) electrode.
C. the concentration of $Cu^{2+}(aq)$ would not be affected.
D. the carbon electrode would become coated with copper.

**Question 15**
If 20 mL of 0.050 M hypochlorous acid is added to 40 mL of water, the pH of resulting solution at 25°C should be closest to
A. 1.3
B. 1.8
C. 4.4
D. 4.7

**Question 16**
The common 12 V car battery consists of 6 lead-acid cells, all of which convert chemical energy into electrical energy via the electrode reactions.

$$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^- \text{ and}$$

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

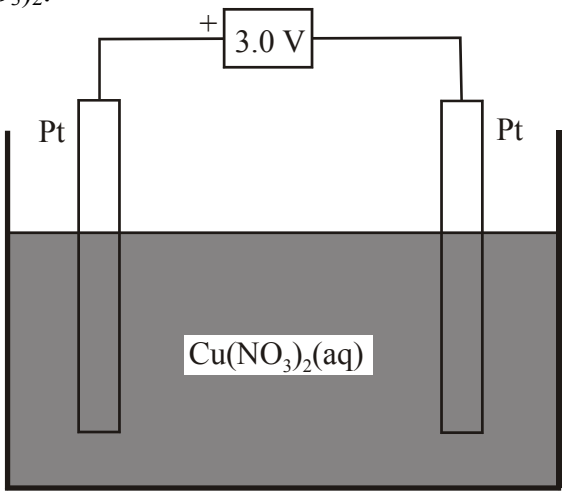
When a car battery is recharged
A. Pb is produced at the negative electrode of each cell.
B. the pH in each cell increases.
C. $PbSO_4$ is produced at the positive electrode in each cell.
D. the changes in the oxidation numbers of lead are from 0 to +2 and +4 to +2.

**Question 17**
Sulfuryl chloride, $SO_2Cl_2$, is produced via a reaction between sulfur dioxide and chlorine, according to the equilibrium

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

Which of the following changes will increase the yield of thionyl chloride?
A. Increasing the temperature.
B. Decreasing the volume of the reaction vessel.
C. Introducing a new catalyst.
D. Decreasing the pressure of the equilibrium mixture.

**Question 18**
In the electrolysis cell shown below, platinum electrodes are placed in 200 mL 0.10 M copper(II) nitrate, $Cu(NO_3)_2$.




When 9650 C of electric charge is passed through this cell, the maximum amount of gaseous product(s) formed would be
A. 0.0250 mol $O_2$.
B. 0.0500 mol $H_2$.
C. 0.0250 mol $O_2$ and 0.030 mol $H_2$.
D. zero, no gaseous products are formed.

**Question 19**
Methanal, $CH_2O$, can be produced from methanol, $CH_3OH$, according to the equilibrium

$$2CH_3OH(g) + O_2(g) \rightleftharpoons 2CH_2O(g) + 2H_2O(g)$$

In an investigation of this equilibrium, a mixture of 3 mol $CH_3OH$ and 3 mol $O_2$ is allowed to reach equilibrium.
The amount of methanal, $CH_2O$, present at equilibrium would be
A. 1.5 mol.
B. less than 3 mol.
C. 3 mol.
D. 6 mol.

**Question 20**
The large scale generation of electrical energy in coal fired power stations involves the following energy changes:

1. Chemical to thermal
2. Thermal to thermal
3. Thermal to mechanical
4. Mechanical to electrical

Which of the energy changes listed is not associated with the generation of electrical energy in nuclear power stations?

A. 1
B. 2
C. 3
D. 4

## End of Section A

# VCE Chemistry 2009 Year 12 Trial Exam Unit 4

## Short Answer Questions - Section B

*Section B consists of 6 short answer questions.*
*You should answer all of these questions.*
*This section is worth approximately 75 per cent of the total marks available.*
*The marks allotted are shown at the end of each part of each question.*
*Questions should be answered in the spaces provided.*

**Question 1**
Converting natural gas into a mixture of carbon monoxide and hydrogen, known as *synthesis gas* (Syngas), is an important intermediate step in many existing and emerging energy conversion technologies. Syngas can be used to produce methanol, used in direct methanol fuel cells (DMFCs).

a. Syngas is commonly produced by steam methane reforming (SMR).

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g); \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

Under investigation is the production of Syngas by catalytic partial oxidation (CPOX) of methane

$$2CH_4(g) + O_2(g) \rightleftharpoons 2CO(g) + 4H_2(g); \qquad \Delta H = -76 \text{ kJ mol}^{-1}$$

i. Explain why there may be a significant cost benefit of producing Syngas by CPOX rather than SMR.

**(2 marks)**

ii. Explain why a rate/yield conflict may exist in the CPOX process.

**(2 marks)**

iii. Identify one applied condition which could, according to Le Chatelier's principle, increase the yield of Syngas in both SMR and CPOX.

**(1 mark)**

iv. Give the name and chemical formula of the 'industrial chemical' you studied in detail during Unit 4, and write a balanced equation for one of the equilibria associated with its production.

**(2 marks)**

v. Identify one applied condition which could theoretically increase the yield in the equilibrium described in (iv) and the production of Syngas by CPOX.

**(1 mark)**

vi. Methanol is produced by passing Syngas over a $Cu/ZnO/Al_2O_3$ catalyst at 250°C. Write a balanced equation for the production of methanol from Syngas.

**(1 mark)**

b. The technology behind Direct Methanol Fuel Cells (DMFC) is still in the early stages of development, but it has been successfully demonstrated powering mobile phones and laptop computers—potential target end uses in future years. The electrolyte in a DMFC is a polymer through which the charge carrier, $H^+$, can move. The end products of the reaction in a DMFC are the same for the combustion of methanol.

i. Write a balanced half-equation for the reaction occurring at the (-) electrode in a DMFC.

**(1 mark)**

ii. Write a balanced half-equation for the reaction occurring at the (+) electrode in a DMFC.

**(1 mark)**

iii. In terms of the fuel used, suggest one advantage that DMFCs may have over a $H_2/O_2$ fuel cell.

**(1 mark)**

***Total 12 marks***

**Question 2**

A bomb calorimeter was used to determine the $\Delta H$ for the combustion of lactic acid, $C_3H_6O_3$. The equation for the reaction is

$$C_3H_6O_3(l) + 3O_2(g) \rightarrow 3CO_2(g) + 3H_2O(g).$$

The following procedure was followed:

1. The calorimeter was calibrated by allowing a 5.000 g sample of ethanol to react completely with oxygen in the calorimeter. The energy released caused the temperature of the calorimeter and its contents to change from 23.11°C to 53.19°C.
2. A 5.865 sample of pure lactic acid was then reacted completely with oxygen in the calorimeter. The energy released caused the temperature of the calorimeter and its contents to change from 23.1°C to 41.6°C.

a. Calculate the calibration factor.

**(3 marks)**

b. Calculate the energy released from the combustion of 5.865 g of lactic acid.

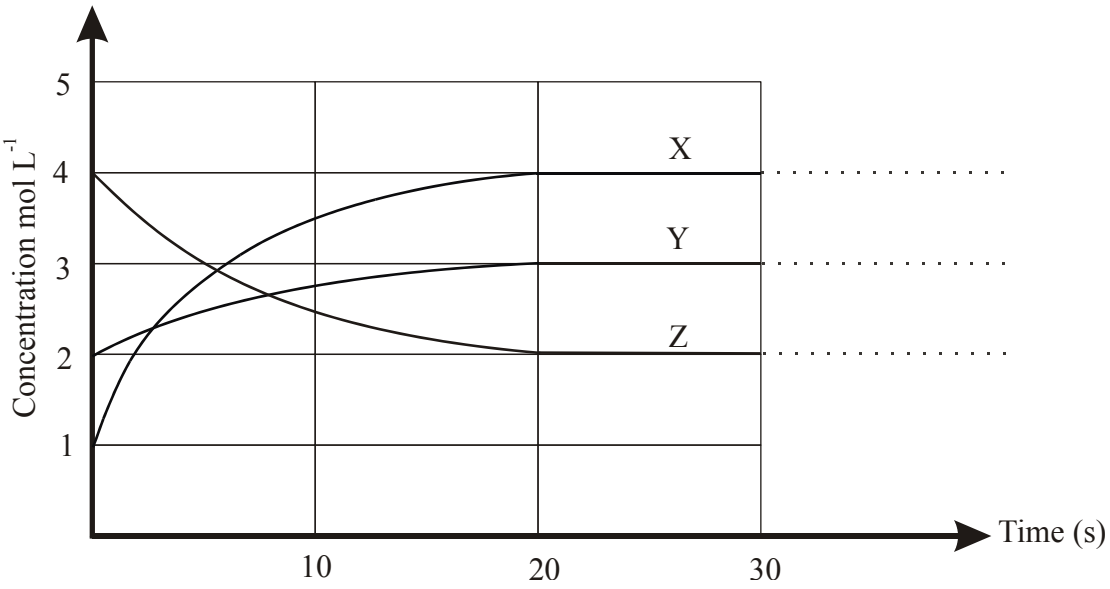
**(2 marks)**

c. Determine $\Delta H$ for the reaction $C_3H_6O_3(aq) + 3O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$.

**(3 marks)**

***Total 8 marks***

**Question 3**
The graph below shows the concentrations, as a function of time, for a mixture of gases, X, Y and Z, added to a one litre container and allowed to reach equilibrium.




a. How long does the mixture take to reach equilibrium?

**(1 mark)**

b. i. Use the information provided on the graph to complete the table below.

| | Initial Concentration | Equilibrium Concentration | How the concentration changes as the system moves to equilibrium |
|---|---|---|---|
| X | | | |
| Y | | | |
| Z | | | |

**(3 marks)**

ii. Use the information in the table in (i) to deduce the equation for the equilibrium reaction.

**(2 marks)**

c. Write the equilibrium law expression and calculate the value of the equilibrium constant.

**(2 marks)**

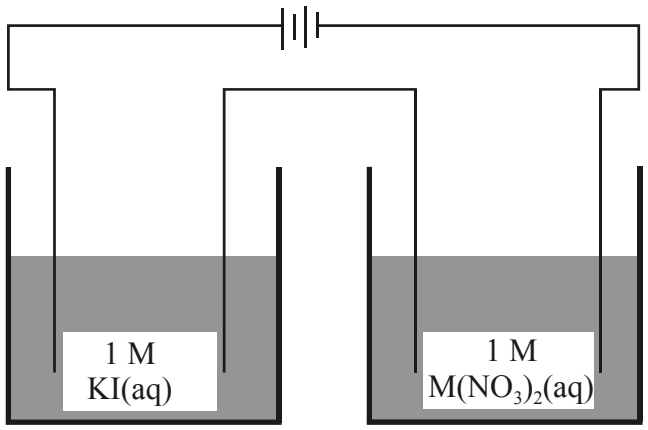
d. At 30 seconds, the volume of the container was doubled. On the concentration time graph, sketch how the concentration of X would change during and after this volume increase.

**(2 marks)**

***Total 10 marks***

**Question 4**

A current of 2.5 A is passed for 50 minutes through two cells connected in series. As indicated on the diagram below, these cells contained 1 M solutions of potassium iodide and a metal nitrate, $M(NO_3)_2$, respectively. Each cell also contains a pair *of platinum electrodes.*




a. Calculate the charge, in Coulombs, passed through each cell.

**(1 mark)**

b. Calculate the amount of electrons, in mole, passed through each cell.

**(1 mark)**

c. During the electrolysis, a metal is deposited on one of the electrodes in the cell containing the metal nitrate, but not in the cell containing potassium iodide. What does this suggest about the relative positions on the electrochemical series of potassium metal and the metal in the metal nitrate?

**(2 marks)**

d. Calculate the mass of the product formed from the reaction at the positive electrode in the potassium iodide cell.

**(2 marks)**

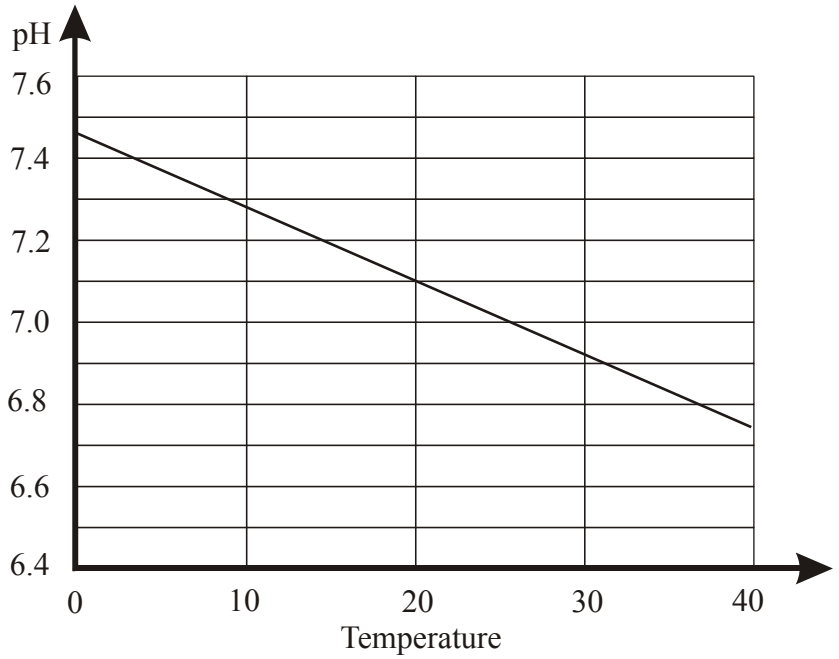
e. During the electrolysis, 2.48 g of the metal is deposited on the cathode in the metal nitrate cell. Identify the metal.

**(2 marks)**

***Total 8 marks***

**Question 5**

a. The graph below shows the variation in pH of pure water with temperature.




i. Explain why the pH of pure water changes with temperature as shown in this graph.

**(2 marks)**

ii. Calculate the $[H_3O^+]$ and $[OH^-]$ in pure water at 35°C.

**(2 marks)**

b. Calculate the pH of 0.10 M propanoic acid.

**(3 marks)**

c. i. Show that when 10 mL of 0.10 M HCl(aq) is diluted to 100 mL with water the pH of the solution increases by 1.

**(2 marks)**

ii. Show that when 10 mL of 0.10 M propanoic acid is diluted to 100 mL with water, the pH increases by less than 1.

**(3 marks)**

iii. Explain why the change in pH is less when 10 mL of 0.10 M propanoic acid is diluted to 100 mL with water, than when 10 mL of 0.10 M hydrochloric acid is diluted to 100 mL with water.

**(3 marks)**

***Total 15 marks***

**Question 6**
Standard electrode potentials associated with half-equations on the electrochemical series, are determined from the cell voltage generated when the half-cell is connected to the standard hydrogen half-cell, under standard conditions, in a functioning galvanic cell.

a. Describe the components and conditions present in a standard hydrogen half-cell.

**(2 marks)**

b. Write an overall equation describing the cell reaction occurring when a standard hydrogen half-cell is connected to a $Cl_2(g)/Cl^-(aq)$ half-cell in an operating galvanic cell.

**(1 mark)**

c. In a different galvanic cell containing the standard hydrogen half-cell, the pH in the standard hydrogen half-cell decreases as the cell delivers energy. Explain how this knowledge enables you to deduce the sign of the electrode in the standard hydrogen half-cell.

**(2 marks)**

d. In the alternative version of the electrochemical series, standard electrode potentials are determined by using the $Cu^{2+}(aq)/Cu(s)$ half-cell as the reference half-cell. Assuming the same standard conditions apply, what would be standard electrode potential of the $Ni^{2+}(aq)/Ni$ half-cell in this alternative electrochemical series? Explain your reasoning.

**(2 marks)**

e. Referring to standard electrode potentials, explain why aluminium cannot be produced by the electrolysis of an aqueous solution of $Al^{3+}$ ions, i.e. $Al^{3+}(aq)$

**(2 marks)**

***Total 9 marks***

## End of Section B

## End of Trial Exam