SECTION A – Multiple-choice questions

Instructions for Section A
Answer all questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No mark will be given if more than one answer is completed for any question.

Question 1

A solution calorimeter was inadvertently calibrated with 105 mL of water instead of 100 mL. The calorimeter was emptied and dried and then used to determine the heat of reaction of powdered zinc in 100 mL of HCl (aq). It can be deduced from this information that the correct calibration factor should be

A. lower and the heat of reaction should be lower.

B. higher and the heat of reaction should be higher.

C. lower and the heat of reaction should be higher.

D. higher and the heat of reaction should be lower.

Question 2

When a freshly cleaned piece of magnesium is placed in **de-oxygenated** water

A. no reaction is predicted

B. hydrogen bubbles only would be formed

C. hydroxide ions only would be formed

D. both hydrogen gas and hydroxide ions are formed

Question 3

At 25 °C, the pH of 100 mL of 0.050 M $Ba(OH)_2$ (aq) is

A. 1.0

B. 1.3

C. 12.7

D. 13.0

Question 4

A student is attempting to determine the Avogadro constant by electrolysing a solution of copper sulfate. Which of the following is **not** needed for the determination?

A.   the mass of copper deposited

B.   the concentration of the copper sulfate solution

C.   the charge, in coulomb, per electron

D.   the amount of current passed through the electrolyte

Question 5

In the production of magnesium and aluminium by electrolysis, for the same quantity of electricity, the simplest ratio of the **mass** of magnesium deposited to the mass of aluminium deposited will be closest to

A.   1:1

B.   3:2

C.   4:3

D.   8:9

Question 6

A gas syringe contains an equilibrium mixture of NO_2 and N_2O_4. When the plunger of the syringe is pulled outwards, all concentrations decrease immediately. Which of the following occurs **subsequently**?

A.   The concentration of NO_2 in the system decreases further while that of N_2O_4 increases.

B.   The concentration of NO_2 in the system increases further while that of N_2O_4 decreases.

C.   All concentrations decrease further in order to restore equilibrium.

D.   All concentrations increase in order to restore equilibrium.

Question 7

Which of the following cannot be extracted commercially from aqueous solution?

A.   nickel

B.   copper

C.   sodium

D.   tin

The next three questions refer to the following information

The cell reaction occurring in a particular button cell as current is drawn is

$Ag_2O(s) + Zn(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s)$.   **The cell potential is 1.50 V**
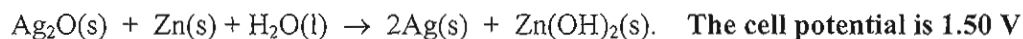
Question 8

In this button cell, zinc forms the

A.   positive electrode and is reduced

B.   positive electrode and is oxidised

C.   negative electrode and is reduced

D.   negative electrode and is oxidised

Question 9

The button cell is used in a hearing aid that draws a current of 0.100 mA. The amount, in mol, of Ag_2O that would be needed to keep the cell running continuously for 12 weeks (7257600 s) is closest to

A. 2.26×10^{-2}

B. 3.76×10^{-3}

C. 1.13×10^{-2}

D. 1.50×10^{-2}

Question 10

Given that the electrolyte in the cell is 1 M KOH (aq) and the Ag_2O / Ag half cell has $E° = + 0.34$ V, then the $E°$ of the $Zn(OH)_2$ / Zn half cell is

A.   - 1.16 V

B.   - 1.84 V

C.   +1.16 V

D.   + 1.84 V

Question 11

A small piece of freshly cleaned silver is placed in an aqueous solution containing magnesium nitrate and copper (II) nitrate. Which of the following occurs?

A.   The silver dissolves and only copper is produced.

B.   The silver dissolves and only magnesium is formed.

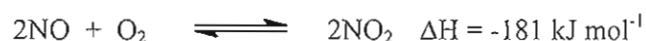C.   A mixture of magnesium and copper is formed.

D.   No reaction occurs.

Question 12

Which of the following species is most common in an aqueous solution of the weak base ammonia?

A. NH_3

B. NH_4^+

C. OH^-

D. H_3O^+

Question 13

A mixture of NO, NO_2 and O_2 are allowed to reach equilibrium, according to the equation

$$2NO + O_2 \rightleftharpoons 2NO_2 \quad \Delta H = -181 \text{ kJ mol}^{-1}$$

If the temperature and pressure of the system were in increased, the amount of NO present when the system returns to equilibrium would be

A.   unchanged

B.   unable to be predicted

C.   increased

D.   decreased

The next two questions refer to the following information

A hypothetical acid-base indicator, HIn, is a weak acid as shown in the equation below.

$$HIn \ (aq) \rightleftharpoons H^+(aq) + In^-(aq) \quad K_a = 1.0 \times 10^{-8} \ M$$

red   blue
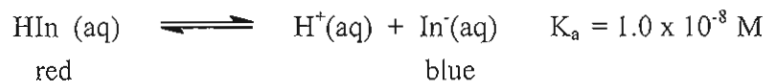
Question 14

If the indicator is added to an acidic solution whose pH is 1.0, the colour of the solution will be

A.   red

B.   blue

C.   green

D.   purple

Question 15

If $[HIn] = [In^-]$, then the colour of the resulting solution will be

A.   red

B.   blue

C.   green

D.   purple

Question 16

Boric acid, H_3BO_3, is commonly used in eyewash solutions in chemistry laboratories to neutralise bases splashed in the eye. It acts as a monoprotic acid but its ionisation reaction is slightly different from that of other acids.
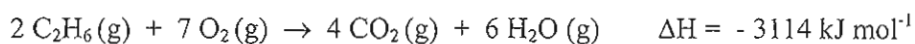
$$B(OH)_3 \ (aq) + H_2O \ (l) \rightleftharpoons H^+(aq) + B(OH)_4^- \ (aq) \quad K_a \approx 5.8 \times 10^{-10}$$
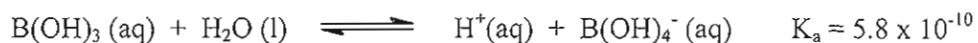
The pH of a 0.50 M solution of boric acid would be closest to

A.   4.0

B.   4.8

C.   7.0

D.   9.2

Question 17

The following is a thermochemical equation for the complete combustion of ethane

$$2\,C_2H_6\,(g) + 7\,O_2\,(g) \rightarrow 4\,CO_2\,(g) + 6\,H_2O\,(g) \qquad \Delta H = -\,3114 \text{ kJ mol}^{-1}$$

If the activation energy of the reaction is 275 kJ **per mole of ethane**, the energy released, in kJ, during bond formation for the reaction as written above will be
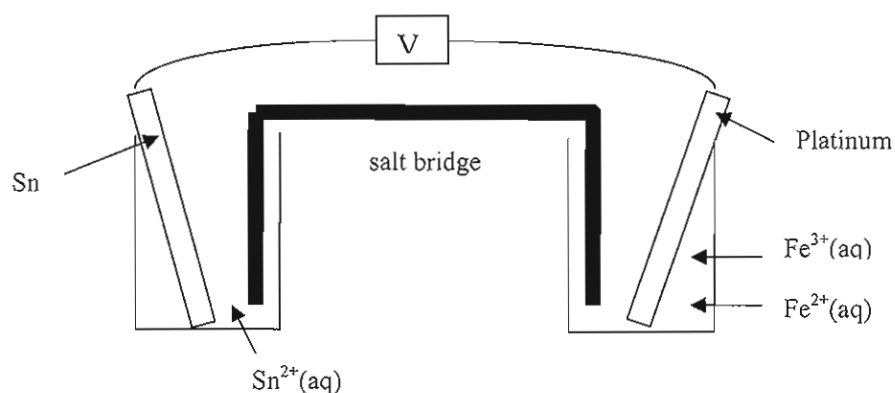
A.   2564

B.   2839

C.   3389

D.   3664

Question 18

A student has 10 mL of a solution of KOH which has a pH = 10. The solution is diluted with de-ionised water to make up a litre of solution. The pH of the diluted solution will be

A.   8

B.   9

C.   11

D.   12

The next two questions refer to the galvanic cell shown below.

Question 19

In the galvanic cell

A.　the Pt electrode is the cathode and Fe^{2+} ions are reduced

B.　the Sn electrode is the cathode and Sn^{2+} ions are reduced

C.　the Pt electrode is the anode and has a negative charge

D.　the Sn electrode is the anode and has a negative charge

Question 20

If the salt bridge was soaked in a saturated solution of KNO_3, then as the cell discharges

A.　K^+ ions will migrate towards the half-cell containing the Sn electrode

B.　K^+ ions will migrate towards the half-cell containing the Pt electrode

C.　NO_3^- ions will migrate towards the half-cell containing the Pt electrode

D.　Sn^{2+} ions will migrate towards the half-cell containing the Sn electrode

END OF SECTION A

SECTION B – Short answer questions

Instructions for Section B

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks.

- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.

- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; $NaCl(s)$

Question 1

Ethanoic acid, CH_3COOH, is a weak acid.

a. Explain what is meant by the term 'weak acid'

_____

_____

1 mark

b. Determine the concentration of ethanoate ion, CH_3COO^-, in a 0.0500 M solution of ethanoic acid at 25 °C.

_____

_____

_____

_____

_____

4 marks

c. A base in water produces hydroxide ions by accepting a proton from water. So an aqueous solution of the **weak** base, sodium ethanoate, CH_3COONa, contains hydroxide ions. Write an **ionic** equation to describe this equilibrium reaction.
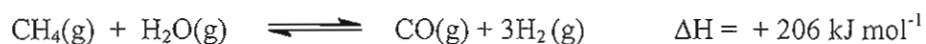
_____

2 marks

d. Write the expression for K_b of the ethanoate ion as described by your equation in part **c**.

_____

_____

1 mark

Total 8 marks

Question 2

In the manufacture of ammonia, hydrogen can be obtained from natural gas by the reaction with steam.

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

a.   Write an expression for K for this reaction.

_____

_____

_____

_____

1 mark

b.   For each of the changes below, what will happen to the value of K_c and explain why?

Change	Effect on K ↑, ↓, no change	Explanation
i. The temperature is increased		
ii. The volume is increased at constant temperature		
iii. A catalyst is used		

6 marks

c.   How will the amount of hydrogen, in mol, be affected by the following changes? Explain each answer.

Change	Effect on amount of H_2 ↑, ↓, no change	Explanation
i. Increasing the pressure at constant temperature		
ii. Increasing the temperature		
iii. Using a catalyst		

6 marks

Total 13 marks

Question 3

An excess of zinc powder was added to 50.0 mL of 0.100 M $AgNO_3$ (aq) in a polystyrene cup. Initially the temperature of the solution was 21.10 °C and during the reaction it rose to 25.40 °C.
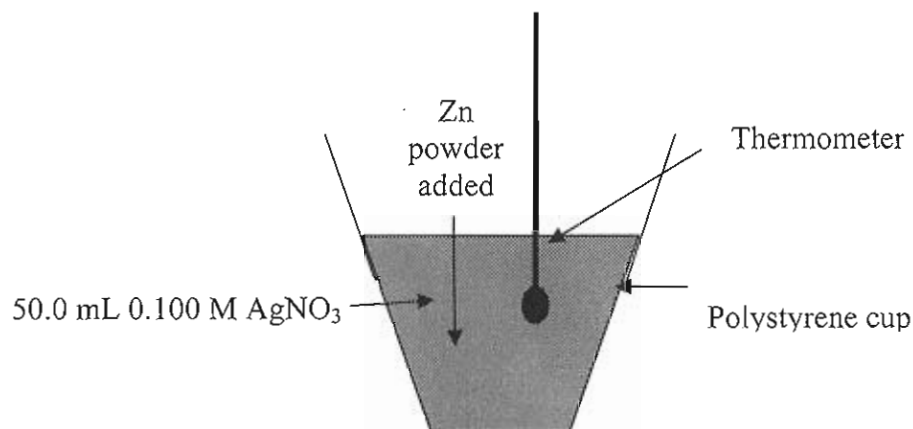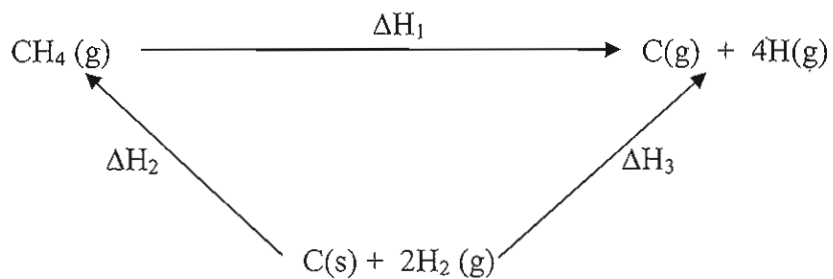

Assuming that the density of the solution is 1.00 g ml^{-1} and ignoring the heat capacity of the metals, calculate the enthalpy change for the reaction

$$Zn\,(s) + 2\,Ag^+\,(aq) \rightarrow Zn^{2+}\,(aq) + 2\,Ag\,(s)$$

4 marks

Question 4

ΔH_1, ΔH_2 and ΔH_3 are energy values for steps in the energy cycle below.

$$CH_4\,(g) \xrightarrow{\quad \Delta H_1 \quad} C(g) + 4H(g)$$

ΔH_2 \quad\quad ΔH_3

$$C(s) + 2H_2\,(g)$$

Given the following standard enthalpies

- formation of methane   = -74 kJ mol^{-1}

- atomisation of hydrogen = +717 kJ mol^{-1}

- atomisation of carbon   = + 218 kJ mol^{-1}

a.   Which enthalpy is represented by ΔH_2?

_____

1 mark

b.   Calculate the value and sign of ΔH_3.

_____

_____

2 marks

c.   Determine the value and sign of ΔH_1.

_____

_____

2 marks

Total 5 marks

Question 5

a.   i.   Blood refrigerated at 4° C was found to have a pH 7.0. From this information, blood at this temperature is

       Acidic /   Basic /   Neutral   (circle your response)

     ii. Explain your response.

_____

_____

_____

_____

                                                             $1 + 1 = 2$ marks

b.   A solution contains 150 g of sodium hydroxide per Litre.

     Calculate the

     i.   [OH-]

_____

     ii. pH of the solution

_____

_____

_____

                                                             $2 + 1 = 3$ marks

                                                              Total 5 marks

Question 6

One of the first known devices to produce electrical energy from chemical energy was Volta's pile. It was a crude form of the modern day dry cell and consisted of alternating zinc and copper discs separated by paper discs soaked in ammonium salt solution. However the device stopped producing electricity as hydrogen gas produced at the cathode polarised the electrode.

a.   Identify the nature of the anode and cathode in Volta's pile and indicate the direction of electron flow.

_____

_____

_____

2 marks

b.   Write the balanced half equation for the reaction occurring at the

    i.   anode

_____

    ii.   cathode

_____

1 + 1 = 2 marks

c.   Explain the two functions of ammonium salt solution.

_____

_____

_____

_____

2 marks

Total 6 marks

Question 7

The diagram below represents an experimental arrangement used by a student to investigate the electrolysis of a mixture of three metal nitrates, 0.010 M $Al(NO_3)_3$, 0.010 M $AgNO_3$, 0.010 M $Cu(NO_3)_2$ The total volume of solution is 100mL. The voltage is carefully increased until electrolysis begins.
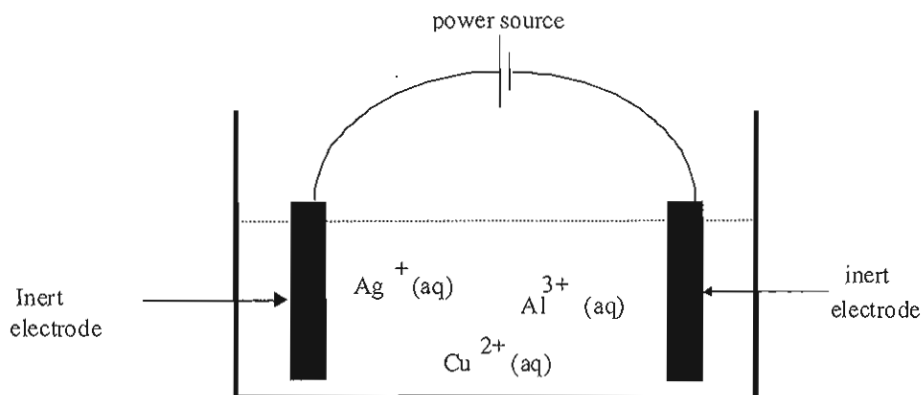
a.   Write an equation for the half reaction that occurs at the cathode when electrolysis first starts.

_____

1 mark

b.   Write an equation for the half reaction at the anode.

_____

1 mark

c.   If the current is 500 mA, how long, in seconds, would it take to complete the plating of the first metal?

_____

_____

_____

_____

_____

5 marks

d.   If the electrodes are cleaned at this stage and the voltage slowly increased until electrolysis occurs, describe what would happen at the cathode.

_____

_____

1 mark

e.   Could all the metals be plated in this way? Explain your answer.

_____

_____

1 mark

Total 9 marks

Question 8

Name the industrial chemical you have studied in depth in Unit 4. _____

For your nominated chemical:

a. Give the balanced equation for the main equilibrium step involved including the sign of the ΔH.

_____

1 mark

b. List the actual conditions for production of the chemical.

_____

_____

_____

3 marks

c. Give **one** environmental feature incorporated into the production of the chemical to minimise effect on the environment.

_____

_____

1 mark

d. Give **two** major uses for the chemical and support each use with a balanced equation.

_____

_____

_____

_____

4 marks

Total 9 marks

END OF EXAMINATION

Use this page as an overlay for marking the multiple choice answer sheets. Simply photocopy the page onto an overhead projector sheet. The correct answers are open boxes below. Students should have shaded their answers. Therefore, any open box with shading inside it is correct and scores 1 mark.

	ONE ANSWER PER LINE		ONE ANSWER PER LINE
1	☐ ▉	11	▉ ☐
2	▉ ☐	12	☐ ▉
3	▉ ☐	13	▉ ☐ ▉
4	▉ ☐ ▉	14	☐ ▉
5	▉ ☐ ▉	15	▉ ☐
6	▉ ☐ ▉	16	▉ ☐ ▉
7	▉ ☐ ▉	17	▉ ☐
8	▉ ☐	18	☐ ▉
9	▉ ☐ ▉	19	▉ ☐
10	☐ ▉	20	▉ ☐ ▉