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*Trial Exam Paper*

# 2008

# CHEMISTRY

# Written examination 2

STUDENT NAME:

## QUESTION AND ANSWER BOOK

*Reading time: 15 minutes*
*Writing time: 1 hour 30 minutes*

**Structure of book**

| Section | Number of questions | Number of questions to be answered | Number of marks |
|---------|--------------------|-----------------------------------|-----------------|
| A | 20 | 20 | 20 |
| B | 9 | 9 | 56 |
| | | | Total 76 |

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

**Materials provided**
- The question and answer book of 19 pages, with a separate data book.
- An answer sheet for multiple-choice questions.

**Instructions**
- Write your **name** in the box provided.
- Remove the data sheet during reading time.
- You must answer the questions in English.

**At the end of the examination**
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

**Students are NOT permitted to bring mobile phones or any other electronic devices into the examination.**

## SECTION A – Multiple-choice questions

### Question 1

Reactant A exists in equilibrium with product B. No other chemical species is present. The graph below shows the effect of increasing pressure and temperature on the equilibrium yield of product B.
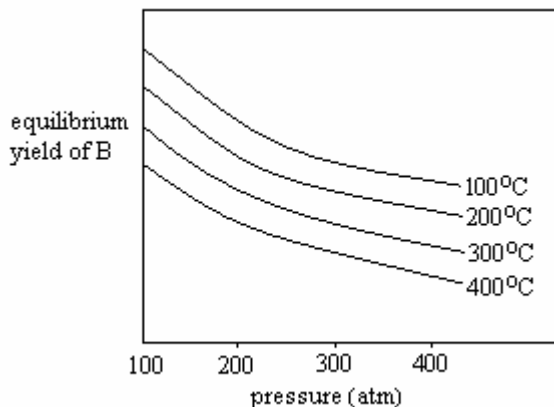


Which one of the following could be a correct equation and $\Delta H$ value for this reaction?

**A.**     $A(g) \rightleftharpoons 2B(g)$            $\Delta H = -64 \text{ kJ mol}^{-1}$

**B.**     $2A(g) \rightleftharpoons B(g)$            $\Delta H = +64 \text{ kJ mol}^{-1}$

**C.**     $A(g) \rightleftharpoons 2B(g)$            $\Delta H = +64 \text{ kJ mol}^{-1}$

**D**.     $A(aq) \rightleftharpoons 2B(aq)$        $\Delta H = -64 \text{ kJ mol}^{-1}$

### Question 2

Which of these Lowry-Bronsted acids would have the **strongest** conjugate base?

**A.**     $H_3BO_3$

**B.**     HF

**C.**     HCl

**D.**     HOCl

### Question 3

Which of the following changes will **always** ensure an increase in the rate of a chemical reaction?

         I       Adding a catalyst

         II      Increasing temperature

         III     Increasing concentration

         IV     Increasing the surface area of the reactant

**A.**     I only

**B.**     I, II and III only

**C.**     I, II and IV only

**D.**     I, II, III and IV

*Questions 4 and 5 refer to the following information.*

Hydrocyanic acid, HCN, is a weak acid. When added to water it reacts according to the equation

$$HCN(aq) + H_2O(l) \rightleftharpoons CN^-(aq) + H_3O^+(aq)$$
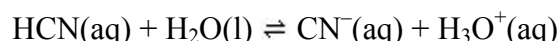
**Question 4**

When three drops of 3.0 M NaOH are added to an equilibrium mixture of HCN in water at constant temperature

**A.**     the pH of the solution decreases.

**B**.     the ratio $\dfrac{[CN^-][H_3O^+]}{[HCN]}$ decreases.

**C**.     the concentration of HCN increases.

**D.**     the concentration of $CN^-$ increases.

**Question 5**

The amount, in mol, of HCN that needs to be dissolved completely in water to form a 1.0 L solution of hydrocyanic acid with a pH of 4.9 is closest to

**A.**     $3.4 \times 10^{-4}$

**B.**     0.25

**C.**     6.8

**D.**     3.7

**Question 6**

Water self-ionises according to the equation

$$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq) \qquad \Delta H = +57 \text{ kJ mol}^{-1}$$

Pure water will have an ionisation constant, $K_w$, of $7.29 \times 10^{-14}$ $M^2$ when the pH and temperature are

|     | **pH** | **Temperature** |
|-----|--------|-----------------|
| **A.** | 7.00 | 25°C |
| **B.** | 6.57 | 5°C |
| **C.** | 6.26 | 55°C |
| **D.** | 6.57 | 55°C |

**Question 7**

A student has two solutions of hydrochloric acid, HCl. Solution A has a pH of 2 and solution B has a pH of 3. It can be deduced that

**A.**     solution A is twice as concentrated as solution B.

**B.**     solution A has a volume ten times greater than solution B.

**C.**     HCl has ionised more completely in solution A than in solution B.

**D.**     solution A is ten times more concentrated than solution B.

**Question 8**

Iron(III) nitrate is added to tin(II) chloride and a reaction occurs. The reactant at the cathode and the polarity of the cathode are

| | Cathode | Polarity of cathode |
|---|---|---|
| **A.** | $Fe^{3+}$ | positive |
| **B.** | $Sn^{2+}$ | positive |
| **C.** | $Sn^{4+}$ | negative |
| **D.** | $Fe^{3+}$ | negative |

**Question 9**

Three half-cells were set up under standard conditions.

| Half-cell | Electrode | Electrolyte |
|---|---|---|
| I | metal A | $A^{2+}(aq)$ |
| II | metal B | $B^{3+}(aq)$ |
| III | metal C | $C^{+}(aq)$ |

When a galvanic cell is constructed from half-cell I and half-cell II, the electrode in half-cell I is positive.
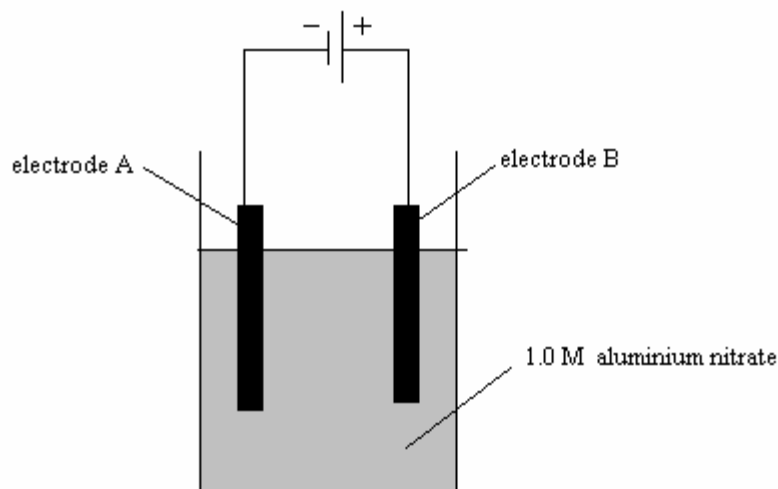
When a galvanic cell is constructed from half-cell I and half-cell III, metal C is deposited at one electrode.

The **increasing** order of reactivity of the metals from least reactive to most reactive is

**A.** A, B, C

**B.** B, A, C

**C.** C, A, B

**D.** C, B, A

**Question 10**

Consider the electrolytic cell shown below, which operates at 25°C. Several drops of indicator solution are added.



A student observing the cell would see

**A.**    bubbles of gas on electrode A and an overall increase in the pH of the solution.

**B.**    bubbles of gas on electrodes A and B.

**C.**    a metallic coating on electrode A and bubbles of gas on electrode B.

**D.**    bubbles of gas on electrode B and an overall decrease in the pH of the solution.

**Question 11**

Which of the following conditions are required for the reliability of the electrochemical series?

I    25°C

II    pH of 7.0

III    1 M

IV    1 atm

**A.**    I, II and III only

**B.**    I, III and IV only

**C.**    I, II, and IV only

**D.**    I and III only

**Question 12**

Which one of the following solutions will have the highest pH if they all have equal concentration?

A.    1.0 M $HNO_3$
B.    1.0 M $H_2SO_4$
C.    1.0 M $NH_3$
D.    1.0 M HF

**Question 13**

A solution calorimeter was calibrated by passing 1.30 A through the electric heater for 2.00 minutes with a potential difference of 7.50 V. A temperature rise of 0.453°C was recorded. The calibration factor of the calorimeter, in J °C$^{-1}$, is

A.    $3.87 \times 10^{-4}$
B.    43.0
C.    530
D.    $2.58 \times 10^3$

**Question 14**

Which one of the following statements about a secondary cell when it is recharging is correct?

A.    Oxidation is occurring at the negatively charged anode.
B.    Electrons are flowing in the direction of cathode to anode.
C.    Electrical energy is being converted to chemical energy.
D.    Electrons are being lost by a chemical species at the negatively charged cathode.

**Question 15**
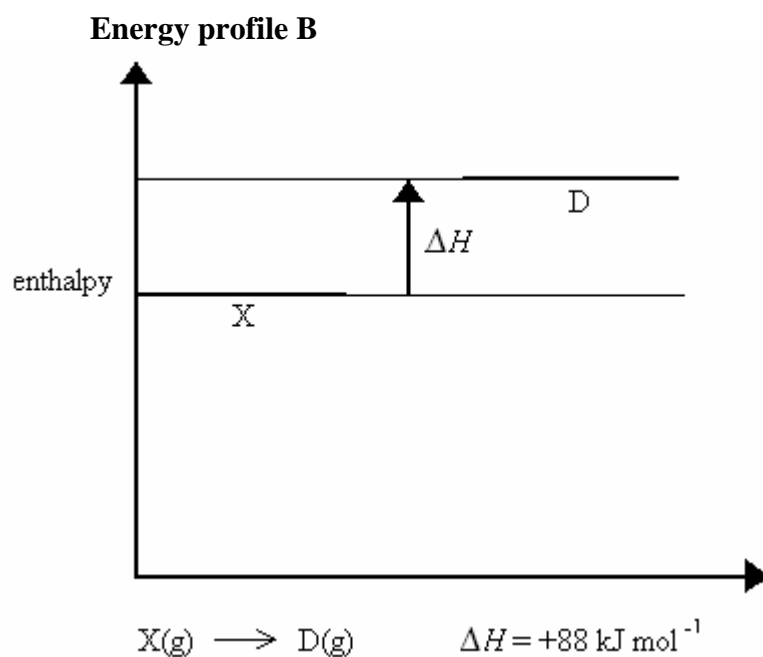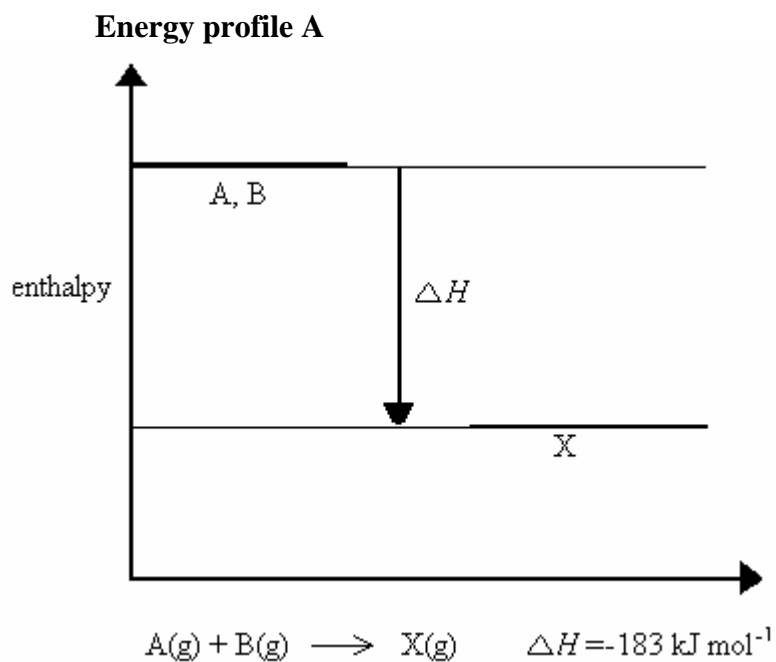
Which of the following is an advantage of nuclear fission over brown coal as an energy source?

I     cost

II    energy output per unit mass of fuel

III   renewable

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

**Question 16**

Consider the following energy profiles for reactions between A and B.

**Energy profile A**



$A(g) + B(g) \longrightarrow X(g) \qquad \Delta H = -183 \text{ kJ mol}^{-1}$

**Energy profile B**



$X(g) \longrightarrow D(g) \qquad \Delta H = +88 \text{ kJ mol}^{-1}$

The value of $\Delta H$, in kJ mol$^{-1}$, for the reaction $A(g) + B(g) \rightarrow D(g)$ is

A.     −95

B.     +95

C.     −366

D.     +366

**Question 17**

An electroplating cell was constructed to deposit a zinc coating onto an iron nail. A voltage of 5.40 V and a current of 0.850 A are passed through a solution of 1 M zinc nitrate, $Zn(NO_3)_2$, for 300 seconds. The mass of zinc produced, in grams, is closest to

**A.**   $1.4 \times 10^{-3}$

**B.**   0.0864

**C.**   0.173

**D.**   0.467

**Question 18**

A chemical reaction has a $\Delta H$ of 235 kJ mol$^{-1}$. The activation energy for its forward reaction is 540 kJ mol$^{-1}$. The activation energy for its reverse reaction, in kJ mol$^{-1}$, is

**A.**   +305

**B.**   −305

**C.**   +540

**D.**   −540

**Question 19**

Which of the following is a demonstration of Faraday's second law of electrolysis?

**A.**   Current (amps) = time (seconds) × charge (coulombs)

**B.**   The mass of lead deposited at the anode of an electrolytic cell is directly proportional to the quantity of energy passed through the cell.

**C.**   The highest reaction in the electrochemical series that can occur in the forward direction is likely to occur at the cathode.

**D.**   The production of one mole of lead requires two moles of electrons to be consumed.

**Question 20**

Which of the following will cause the calculated enthalpy value for an exothermic reaction carried out in a bomb calorimeter to be lower than the actual value?

I       poor insulation

II      a thermometer that reads 3°C lower than the actual temperature

III     a volume of water that was incorrectly measured and is more than it should be

IV      a poorly fitting lid

**A.**   I only

**B.**   I, II and IV
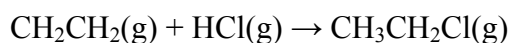
**C.**   I, III and IV

**D.**   I, II, III and IV

**END OF SECTION A**

# SECTION B – Short-answer questions

### Question 1

Ethene and hydrogen chloride can react to produce chloroethane according to the equation

$$CH_2CH_2(g) + HCl(g) \rightarrow CH_3CH_2Cl(g)$$

Some ethene and hydrogen chloride are placed in a sealed container and allowed to react at a fixed temperature. The graph below shows the range of energies possessed by the particles in the container and the number of particles with each particular energy.
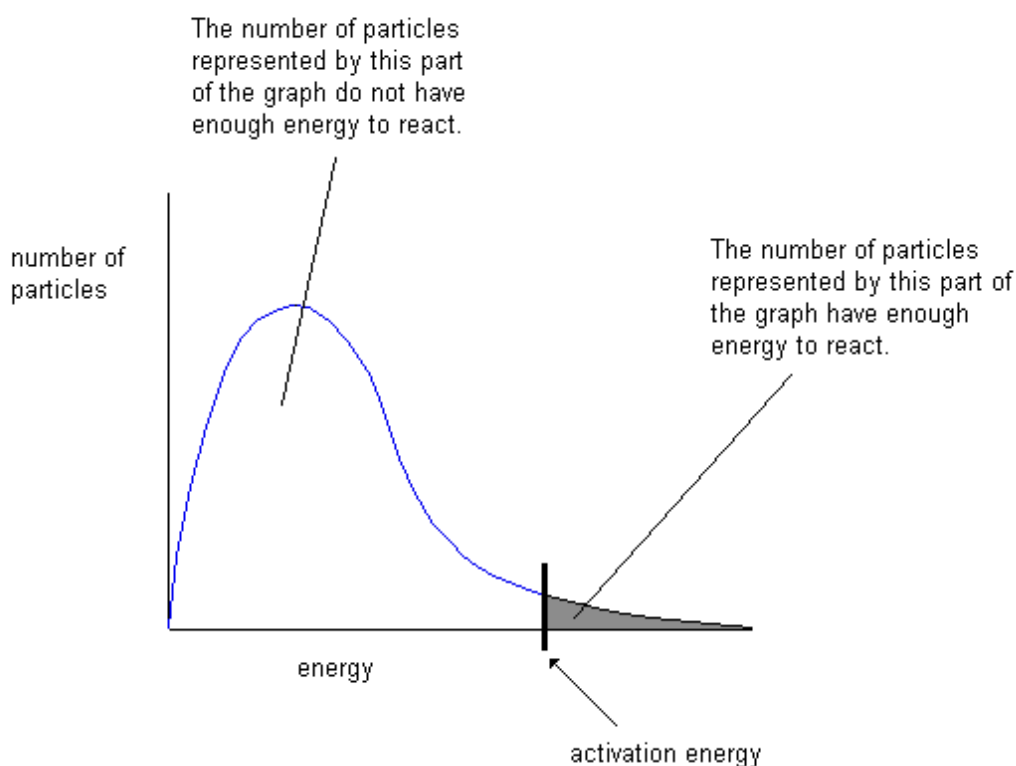


**1a. i.** On the graph above, draw a line to show how the energies of the particles would differ if the temperature of the reaction vessel is increased. **Label this line.**

**ii.** On the graph above, mark with a line the new position of the activation energy if a catalyst was added to the vessel. **Label this line.**

$1 + 1 = 2$ marks

**1b.** The collision theory model can be used to explain the rates of chemical reactions.

**i.** In terms of collision theory, explain what is needed for a chemical reaction to occur.

_____

_____

_____

**ii.** Indicate what effects the following changes would have on a particular reaction mixture by placing ticks in appropriate boxes.

| Change | Changes the activation energy | Increases the total number of collisions between reactant particles | Increases the fraction of collisions with energy above the activation energy |
|---|---|---|---|
| Adding increased amounts of ethene and hydrogen chloride to the same volume container | | | |
| Increasing the temperature | | | |

1 + 2 = 3 marks

**c.** As the reaction between ethene and hydrogen chloride proceeds, would you expect the reaction rate to increase or decrease? Give a reason for your answer.

_____

_____

_____

1 mark

Total 2 + 3 + 1 = 6 marks

**Question 2**

The equilibrium constant for a chemical reaction occurring at a fixed temperature with gaseous reactants and products can be expressed as

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

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

_____

_____

2 marks

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

_____

_____

1 mark

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

_____

_____

1 mark

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

_____

_____

1 mark

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

_____

_____

2 marks

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

_____

_____

_____

_____

_____

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_____
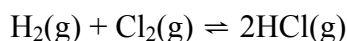
4 marks
Total 2 + 1 + 1 + 1 + 2 + 4 = 11 marks

**Question 3**

Hydrogen gas and chlorine gas are introduced to a reaction vessel according to the equation

$H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$

Once equilibrium is reached, the reaction vessel is heated.

**a.** State the effect of increasing temperature on the concentration of HCl.

_____

1 mark

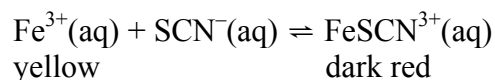**b.** State the effect of increasing temperature on the pressure within the vessel.

_____

_____

_____

1 mark

In solution, the following equilibrium is established between $Fe^{3+}$, which is a yellow colour, $SCN^-$, which is colourless, and $FeSCN^{2+}$(aq), which is a dark red colour.

$Fe^{3+}$(aq) + $SCN^-$(aq) $\rightleftharpoons$ $FeSCN^{3+}$(aq)
yellow                          dark red

**c.** Complete the table by predicting the effect of each of the following changes on the colour of the solution, once a new equilibrium is established, by placing a tick in the appropriate boxes. The temperature is kept constant.

| Change | No change | Colourless | More yellow | Darker red |
|---|---|---|---|---|
| Addition of $FeCl_3$(aq) | | | | |
| Addition of KSCN(aq) | | | | |
| Dilution with water | | | | |

3 marks

An equilibrium mixture contains the gases $Cl_2$, $F_2$ and $ClF_3$.

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

_____

1 mark

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

_____

_____

_____

_____

_____

2 marks

**f.** Calculate the initial concentration, in mol $L^{-1}$, of benzoic acid that is required to produce an aqueous solution of benzoic acid that has a pH of 2.54.

_____

_____

_____

_____

2 marks

Total $1 + 1 + 3 + 1 + 2 + 2 = 10$ marks

**Question 4**

In VCE Chemistry Unit 4, you were required to investigate the industrial production of one chemical selected from ammonia, ethene, sulfuric acid or nitric acid.

**a.** State the name **and** describe a major use of the chemical you studied.

_____

_____

1 mark

**b.** Write a balanced chemical equation for the final reaction that occurs during the production of this chemical; that is, where your chosen chemical will be a product.

_____

_____

1 mark

**c.** Briefly describe one way in which waste generated by the production of this chemical is managed.

_____

_____

_____

_____

1 mark

**d.** Describe a safety risk associated with the production of this chemical and describe what steps are taken as a precaution against this risk.

_____

_____

_____

_____

2 marks

Ethanol can be produced industrially by reacting ethene with steam according to the equation
$$CH_2CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \qquad \triangle = \text{-45 kJ mol}^{-1}$$
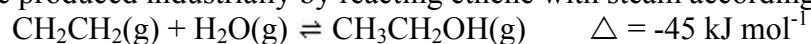
The reaction conditions are:
$T = 300^oC$
$P = 60\text{-}70$ atm
Catalyst = phosphoric(V) acid

**e.** A conflict is involved in choosing the best temperature for this reaction. Suggest a reason for this conflict and explain how it will be resolved.

_____

_____

_____

_____

_____

2 marks

**f.**   If a higher pressure was used it would result in a greater equilibrium yield of ethanol. Suggest why a higher pressure is not used.

_____

_____

_____

1 mark
Total 1 + 1 + 1 + 2 + 2 + 1 = 8 marks

**Question 5**

An instant gas hot water service is listed on the online auction site eBay. The water is heated by the combustion of liquid petroleum gas (LPG).

**a.** Calculate the quantity of energy, in kJ, required to heat the water required for a 4-minute shower to 40°C above room temperature. An average shower uses 15.0 L of water per minute.

_____

_____

_____

2 marks

LPG is a mixture of hydrocarbon gases, primarily propane, $C_3H_8$, and butane, $C_4H_{10}$. A particular brand of LPG contains 60% by mass of propane and 40% by mass of butane.

**b.** Write thermochemical equations for the complete combustion of propane and butane. Include the value and sign of $\Delta H$ for each equation.

**i.** Propane

_____

_____

2 marks

**ii.** Butane

_____

_____

2 marks

**c.** Calculate the mass of LPG required to heat the water for a 4-minute shower, as described in part **a**.

_____

_____

_____

_____

_____

_____

2 marks

Total 2 + 2 + 2 + 2 = 8 marks

**SECTION B** – continued

**Question 6**

Give concise explanations for each of the following.

**a.** Lithium exists only in nature as part of a compound and not as an element.

_____

_____

<div align="right">1 mark</div>

**b.** A reaction will occur when nickel is placed in a 1.0 M solution of iron(III) nitrate, $Fe(NO_3)_3$(aq) but no reaction occurs when nickel is placed in a solution of iron(II) nitrate, $Fe(NO_3)_2$(aq).

_____

_____

_____

<div align="right">1 mark</div>

**c.** Hydrogen and oxygen gas are the only products when a solution of potassium chloride undergoes electrolysis.

_____

_____

<div align="right">1 mark</div>

**d.** Less time is required to produce 10.0 g of gold by electrolysis using a current of 4.5 A than to produce 10.0 g of silver by electrolysis using the same current.

_____

_____

_____

<div align="right">1 mark<br>Total 1 + 1 + 1 + 1 = 4 marks</div>

**Question 7**

To determine the concentration of alcohol in a driver's breath, a fuel cell is used as one type of 'breathalyser'. Ethanol, $C_2H_5OH$, is oxidised to ethanoic acid, $CH_3COOH$, at one electrode and oxygen from air is converted to water at the other. An acidic electrolyte is used.

**a.**    Write the equations for the half-reactions at the anode and the cathode.

Anode _____

Cathode _____

                                                                                  2 marks

**b**.    Write an overall equation for this reaction.

_____

_____

                                                                                  1 mark

**c.**    State the polarity of the anode in this cell.

_____

                                                                                  1 mark

**d.**    State the formula of the reductant in this cell.

_____

                                                                                  1 mark

**e.**    **i.**  A car driver who has consumed alcohol blows into the breathalyser. If the breath entering the cell provides alcohol at a rate of $2.7 \times 10^{-5}$ g per second, calculate the amount, in mol, of ethanol blown into the fuel cell per second and, therefore, the amount of electrons available for reaction.

_____

_____

_____

_____

                                                                                  2 marks

**ii.** Use your answer to part **e i.** to calculate the charge carried by this amount of electrons and, hence, calculate the current produced per second.

_____

_____

_____

_____

*2 marks*
Total 2 + 1 + 1 + 1 + 2 + 2 = 9 marks

**END OF QUESTION AND ANSWER BOOK**