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2021 Trial Examination

STUDENT NUMBER | | | | | | | | | Letter |

CHEMISTRY

Unit 3 – Written examination

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

QUESTION & ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	6	6	67
			Total 87

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- A scientific calculator is permitted in this examination.

Materials supplied

- Question and answer book of 23 pages.

Instructions

- Print your student number in the space provided on the top of this page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the examination room.

Instructions for Section A

Answer **all** questions.

Choose the response that is **correct** or **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

No mark will be given if more than one answer is completed for any question.

Marks will **not** be deducted for incorrect answers.

Question 1

Petrodiesel has been used for many years in ocean liners, farming machinery and mining trucks. Biodiesel has recently emerged as an alternative to petrodiesel. Which one of the following statements regarding biodiesel is **incorrect**?

A. Biodiesel has a lower energy content than petrodiesel and so more biodiesel must be burned than petrodiesel to produce the same amount of energy.

B. Biodiesel produces less particulates than petrodiesel.

C. Biodiesel is more hygroscopic than petrodiesel absorbing water molecules and is more likely to freeze than petrodiesel in colder climates.

D. Biodiesel has a higher viscosity than petrodiesel which means it flows more easily along fuel lines than petrodiesel.

Use the following information to answer Questions 2 and 3

The chemical equation for the combustion of propane, a major component of liquefied petroleum gas, is:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Question 2

The amount of energy produced when 250.0 g of propane undergoes complete combustion is closest to

A. 390.8 kJ

B. 286.0 kJ

C. 12.61 MJ

D. 555.0 MJ

Question 3

The volume of CO_2 gas produced at SLC from 250.0 g of propane in L, is

A. 140.9

B. 422.7

C. 46.97

D. 4.365

Use the following information to answer Questions 4 and 5

An unknown mass of methanol undergoes combustion in a spirit burner. The energy released is used to heat 50.00 g of water in a metal can.

Question 4

If the temperature change of the water is found to be 21.70 ^{o}C, the mass of methanol burnt, in g, is

A. 199.79

B. 0.1998

C. 5.005

D. 102.95

Question 5

In reality, when experiments such as this are undertaken in a laboratory, the results are often inaccurate. Which of the following situations is **unlikely** to have occurred?

A. Not all the energy will be used to heat the water so the temperature rise will be lower than it should be.

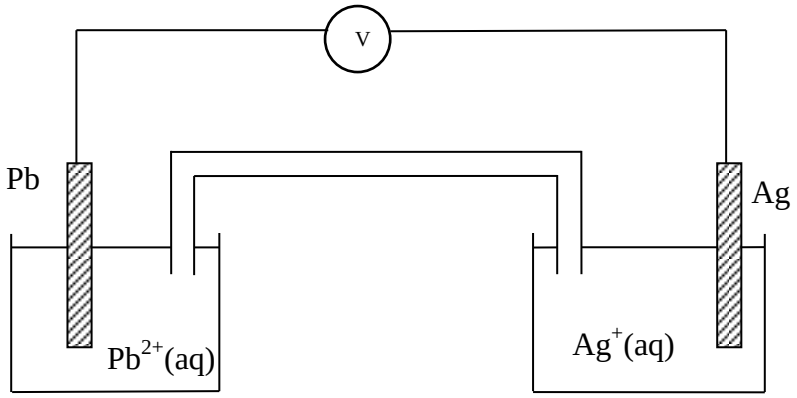
B. Some of the heat released by the spirit burner would be used to heat the metal can holding the water and to heat the air surrounding the can.

C. The combustion of the methanol may have been incomplete, and as a consequence, less energy would have been released than anticipated.

D. Because of the loss of heat during this experiment, it is likely that the mass of methanol burnt would have been overestimated.

Use the following information to answer Questions 6 and 7

The following galvanic cell was set up under standard conditions:



Question 6

The overall equation for the reaction occurring in this galvanic cell is

A. $Pb(s) + 2Ag^{+}(aq) \rightarrow Pb^{2+}(aq) + 2Ag(s)$

B. $Pb^{2+}(s) + 2Ag(aq) \rightarrow Pb(aq) + 2Ag^{2+}(s)$

C. $Pb(s) + Ag^{+}(aq) \rightarrow Pb^{2+}(aq) + Ag(s)$

D. $Pb^{2+}(s) + Ag(aq) \rightarrow Pb(aq) + Ag^{2+}(s)$

Question 7

At standard conditions, the maximum voltage produced by this cell would be predicted to be

A. 0.93 V

B. 0.67 V

C. 1.73 V

D. 0.80 V

Question 8

A student has set up a galvanic cell using half cells constructed as follows:

Half cell 1: a calcium electrode in a beaker containing an aqueous solution of Ca^{2+} ions.

Half cell 2: a platinum electrode in a beaker containing an aqueous solution of a mixture of Fe^{3+} and Fe^{2+} ions

A salt bridge connects the two beakers.

The electrodes are connected to a voltmeter.

This cell is impractical because

A. There is no solid iron (Fe) in the half cell containing Fe^{2+} and Fe^{3+} ions

B. Ionic compounds of calcium tend to be insoluble in water.

C. Fe^{3+} will be in contact with Ca and will oxidise it to Ca^{2+}

D. Solid calcium (Ca) will react directly to reduce water to hydrogen gas.

Question 9

The reaction occurring at the cathode of an alkaline hydrogen fuel cell would be:

A. $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

B. $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$

C. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

D. $O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O(l)$

Question 10

As concerns for the environment continue to grow, efforts have been made to obtain fuels for combustion engines as an alternative to the octane sourced from crude oil. Fuel cells, such as the acidic ethanol fuel cell are being considered by car manufacturers as an alternative way of powering vehicles. The combustion of ethanol and the combustion of octane release similar amounts of energy per mole of carbon dioxide produced. Which of the following is a disadvantage of using an ethanol fuel cell instead of an internal combustion engine powered by octane?

A. Fuel cells are more efficient than internal combustion engines.

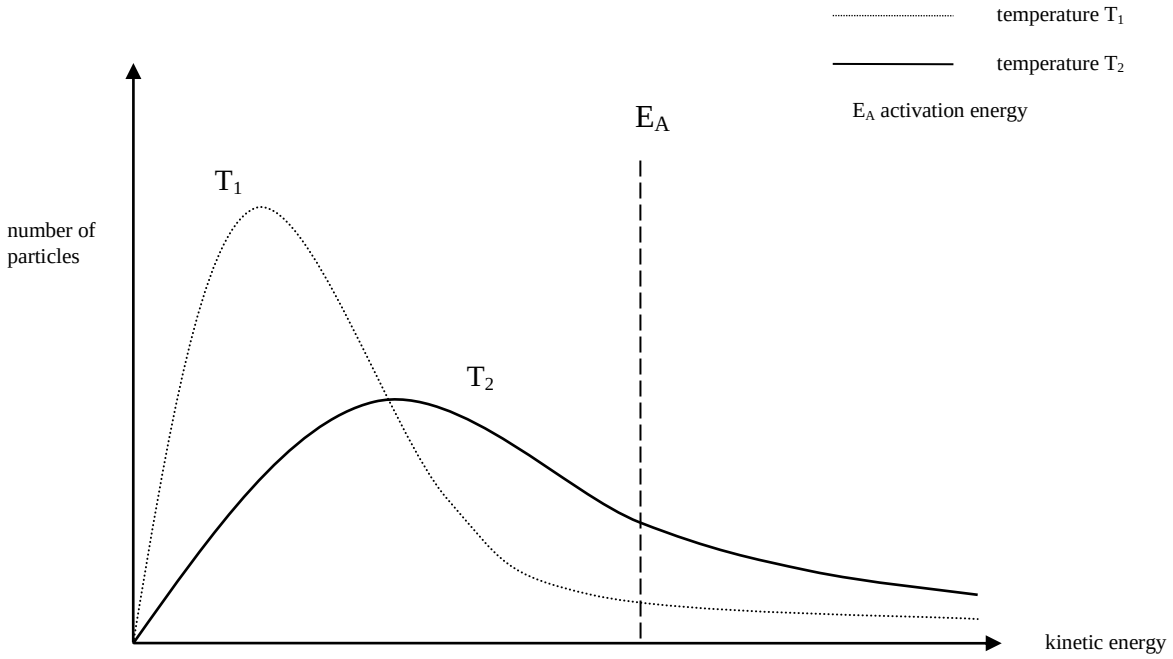
B. The energy content of ethanol is less than that of octane.

C. Ethanol burns more cleanly than octane and produces less particulates.

D. Ethanol can be produced renewably.

Question 11

The diagram below represents the distribution of energy of reactant particles in a sample at two different temperatures. Assume that the areas under the Maxwell-Boltzman curves are equal.



Which of the following conclusions can be made based on this diagram:

A. The temperature T_1 is greater than the temperature T_2

B. At T_1, a greater number of particles have sufficient energy to react than at T_2

C. The activation energy for T_1 is greater than the activation energy for T_2

D. At T_2, a greater number of particles have sufficient energy to react than at T_1

Question 12

Zinc reacts with hydrochloric acid to produce hydrogen gas.

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Which of the following would **not** increase the rate of this reaction?

A. Increasing the temperature of the HCl by 20^oC

B. Increasing the concentration of the hydrochloric acid

C. Allowing the hydrogen gas to escape the reaction vessel

D. Decreasing the size of the solid zinc particles

Question 13

The decomposition of dinitrogen tetroxide (N_2O_4) to nitrogen dioxide (NO_2) is an example of a reversible reaction that reaches a dynamic equilibrium. The reaction occurs according to the following equation:

$N_2O_4(g) \leftrightharpoons 2NO_2(g)$ K at $250^OC = 0.73$ M

Four flasks containing mixtures of the two gases are heated to 250^oC. The concentrations of the N_2O_4 and NO_2 are given below. Identify the flask that is at equilibrium.

	$[N_2O_4]$	**$[NO_2]$**
A.	0.0078	0.08
B.	0.50	0.20
C.	0.0022	0.04
D.	2.10	1.20

Use the following information to answer Questions 14 and 15

$$Fe^{3+}(aq) + SCN^-(aq) \leftrightharpoons Fe(SCN)^{2+}(aq)$$

The Fe^{3+} ion is pale yellow and SCN^- is colourless. The intense, blood-red colour of the solution is due to the presence of the $Fe(SCN)^{2+}$ ion.

Question 14

The colour of the solution becomes lighter when the temperature of the solution is increased. What can be concluded about the equilibrium reaction?

A. The forward reaction is exothermic as an increase in temperature shifts the equilibrium position to the left.

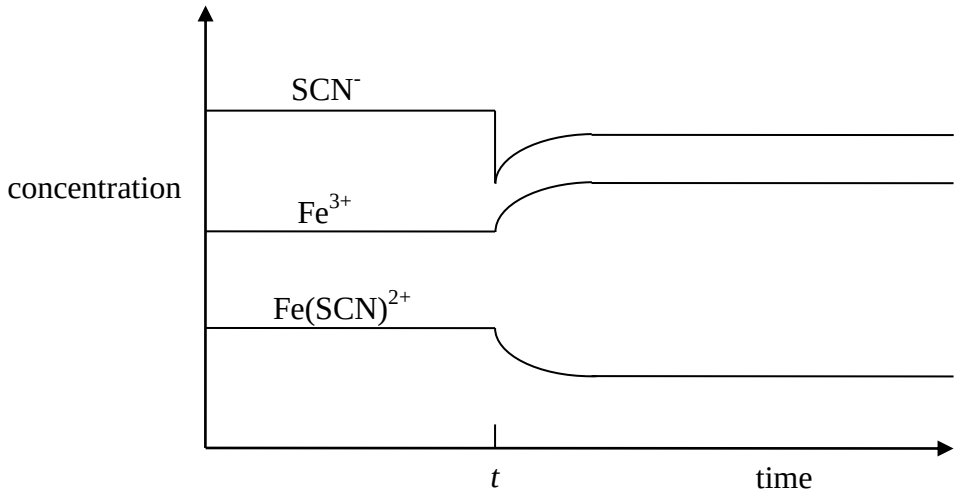
B. The forward reaction is endothermic as an increase in temperature shifts the equilibrium position to the left.

C. The reverse reaction is exothermic as an increase in the temperature will shift the equilibrium position to the left.

D. The reverse reaction is exothermic as an increase in the temperature will shift the equilibrium position to the right.

Question 15

A concentration-time graph for this equilibrium system is shown below:



What event occurred at time *t* to cause the change in equilibrium concentrations?

A. The pressure was decreased at constant temperature.

B. A few drops of $FeCl_3$ were added to the mixture.

C. A catalyst was added at a constant temperature

D. $AgNO_3$ was added to the mixture, forming a precipitate of AgSCN.

Question 16

Nitrogen monoxide reacts with hydrogen according to the following equation:

$$2NO(g) + 2H_2(g) \leftrightharpoons N_2(g) + 2H_2O(g)$$

The equilibrium constant for the reaction at a certain temperature is $6.5 \times 10^2\ M^{-1}$.

The magnitude of the equilibrium constant of the reaction

$$\tfrac{1}{2}\ N_2(g) + H_2O(g) \leftrightharpoons NO(g) + H_2(g)$$

at the same temperature is

A. 3.25×10^2

B. 3.9×10^{-2}

C. 3.08×10^{-3}

D. 1.54×10^{-3}

Question 17

Which of the following statements are true when comparing a galvanic cell with an electrolytic cell?

A. the anode is negative and the cathode is positive in both cells

B. oxidation occurs at the anode in both cells

C. reduction occurs at the positive electrode in an electrolytic cell

D. in a galvanic cell oxidation occurs at the positive electrode

Question 18

Electrolysis of a molten substance containing a metal ion, M^{x+}. A current of 0.75 A applied for 2 minutes yielded 4.66×10^{-4} mol of metal. The value of the charge, x, on the metal ion is

A. 1

B. 2

C. 3

D. 4

Question 19

A student electrolyses a concentrated solution of potassium chloride using inert electrodes. What are the gaseous products formed at each electrode?

	anode	**cathode**
A.	Cl_2	H_2
B.	Cl_2	K
C.	O_2	H_2
D.	H_2	Cl_2

Question 20

Nickel-cadmium cells are rechargeable cells that have been used to power the Russian module of the International Space Station. When the cell is being used, the electrode reactions are represented by the following equations:

$$NiO_2(s) + 2H_2O(l) + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$$

$$Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$$

Which of the following occurs during the recharging of the nickel-cadmium cell?

A. The direction of the electron flow in the external circuit is from the cathode to the anode.

B. The pH of the electrolyte increases.

C. Oxidation of $Ni(OH)_2$ occurs at the negative anode.

D. Cadmium is deposited on the negative electrode.

END OF SECTION A
TURN OVER

SECTION B - Short-answer questions

Instructions for Section B

Questions must be answered in the spaces provided in this book.

To obtain full marks for your responses you should

- Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- Show all workings 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 (12 marks)

Ethanol can be used as fuel in motor vehicles in two different ways.

a. Ethanol is blended with petrol in Australia and sold as E10 at many service stations.

i. Write a balanced thermochemical equation for the complete combustion of ethanol.

2 marks

ii. Calculate the energy released when 1.00 kg of ethanol undergoes complete combustion.

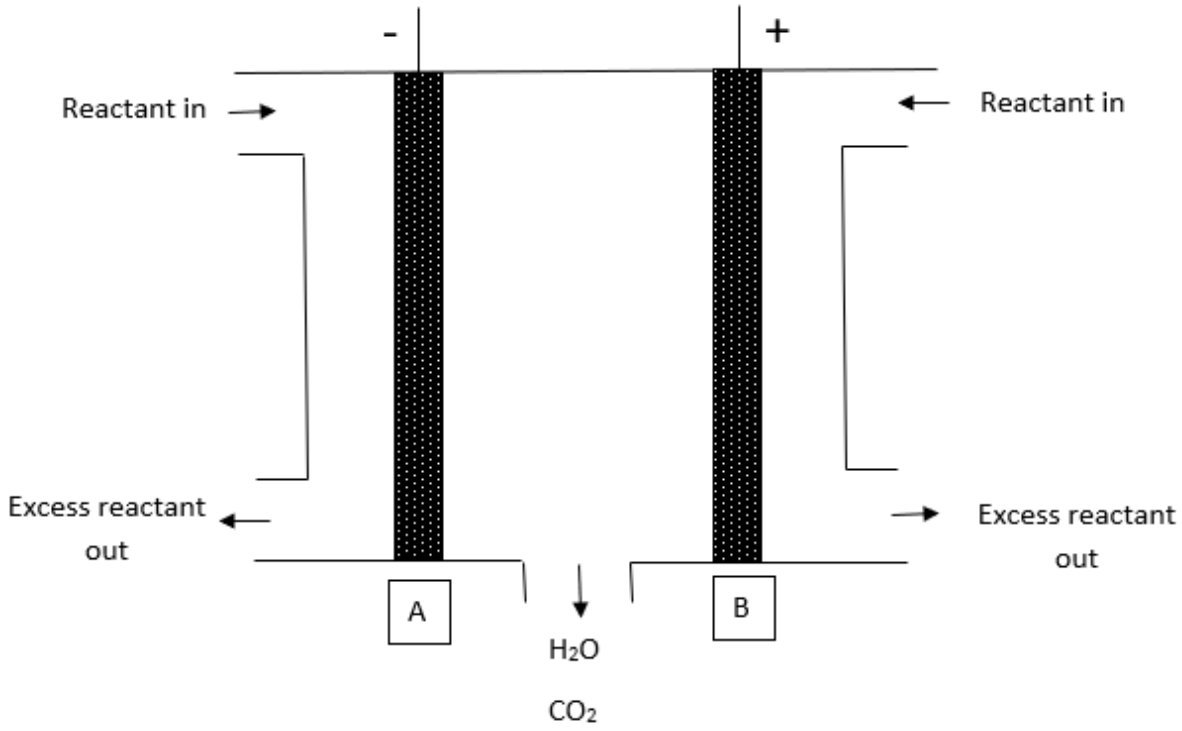
2 marks

iii. The carbon dioxide and water vapour released during the combustion of ethanol are both greenhouse gases. Calculate the volume of carbon dioxide released at SLC during the combustion of 1.00 kg of ethanol.

1 mark

SECTION B - Question 1- continued
TURN OVER

b. Ethanol is also being investigated by car manufacturers for use in an acidic ethanol fuel cell. A diagram of the acidic ethanol fuel cell is shown below.



i. Identify the electrode labelled A as the anode or the cathode.

_____

1 mark

ii. Write the half equation for the reaction occurring at electrode A (states not required).

_____

1 mark

iii. Write the half equation for the reaction occurring at electrode B (states not required).

_____

1 mark

SECTION B - Question 1- continued
TURN OVER

iv. The nature of the electrodes in a fuel cell is critical to the functioning of the fuel cell. Name two features that are typical for electrodes in fuel cells.

2 marks

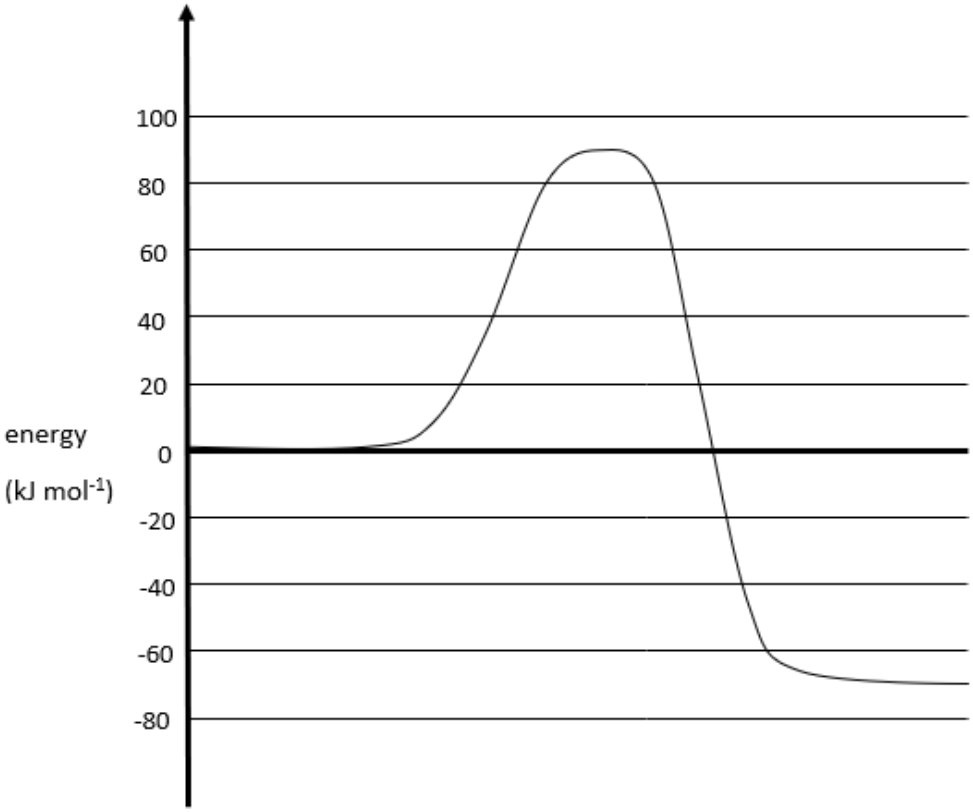
v. Bioethanol may be used instead of ethanol sourced from fossil fuels. What are the advantages of this?

2 marks

SECTION B - continued
TURN OVER

Question 2 (5 marks)

The energy profile diagram below represents a chemical reaction.



Use this diagram to answer the questions below.

a. Is this reaction exothermic or endothermic? Explain your answer in terms of the relative enthalpies of the reactants and products.

2 marks

SECTION B - Question 2 continued
TURN OVER

b. What is the heat of reaction, ΔH, for this chemical reaction?

1 mark

c. What is the activation energy for the reverse reaction?

1 mark

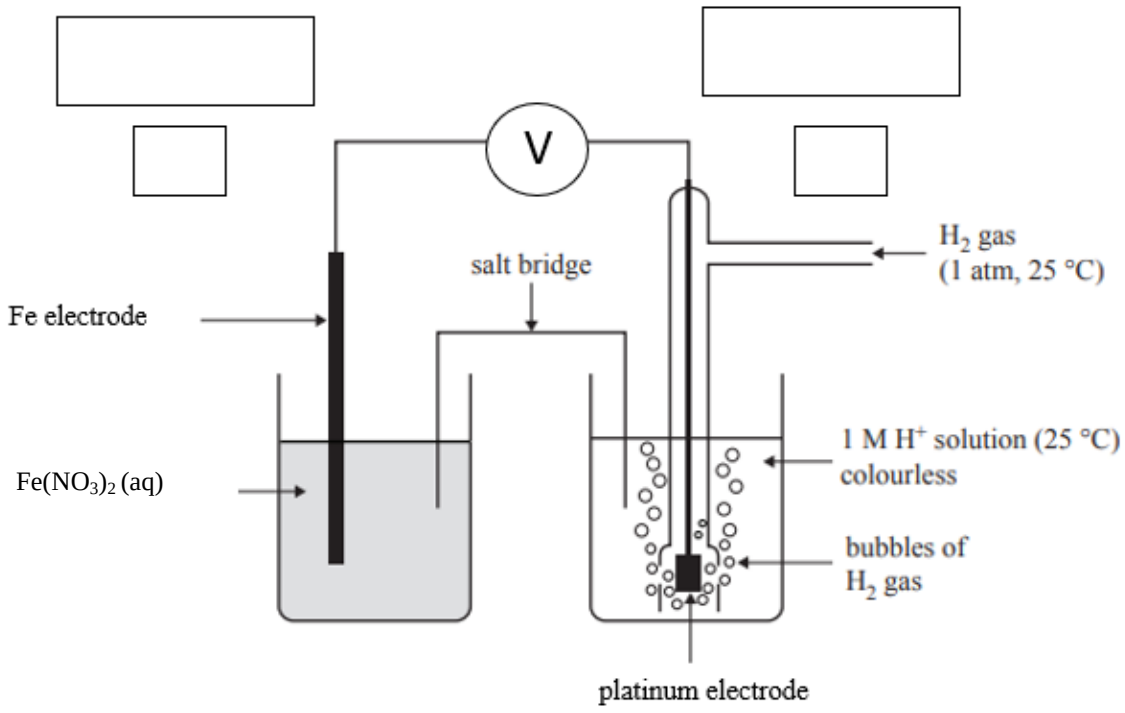
d. On the diagram on the previous page, show how the energy profile would change if a catalyst is added to the reaction mixture.

1 mark

SECTION B - continued
TURN OVER

Question 3 (12 marks)

The following diagram shows a galvanic cell set up in a laboratory. The right-hand side half-cell is a standard hydrogen electrode (SHE) into which hydrogen is continuously bubbled. The half-cell on the left contains a solid Fe rod in a pale green solution of $Fe(NO_3)_2$.



a. Provide the following labels to the diagram:

i. anode and cathode

ii. electrode polarities

iii. direction of electron flow

3 marks

b. Write down the half-cell reaction

i. at the anode

1 mark

ii. at the cathode

1 mark

SECTION B - Question 3 continued

TURN OVER

c. Write down the overall reaction

1 mark

d. Identify the oxidising agent.

1 mark

e. Name a suitable salt for the salt bridge.

1 mark

f. What design features of this galvanic cell allow it to produce electrical energy?

2 marks

g. List two visible changes that will be observed after a period of time.

2 mark

SECTION B - continued
TURN OVER

Question 4 (15 marks)

Consider the reaction shown in the following equation in which a red gas, nitrosyl bromide, is formed by the reversible reaction between nitric oxide and bromine gas.

$$2NO(g) + Br_2(g) \leftrightharpoons 2NOBr(g) \quad \Delta H = -16.1 \text{ kJ mol}^{-1}$$

a. Predict the effect of each change given below on the rate of production of nitrosyl bromide. Circle your prediction (increase, no change or decrease) and explain your reasoning.

i. Decreasing temperature at constant volume

increase no change decrease

Reasoning:

2 marks

ii. Increasing pressure at constant temperature

increase no change decrease

Reasoning:

2 marks

SECTION B – Question 4 continued
TURN OVER

b. In industry, manufacturers monitor the conditions on an equilibrium system in order to maximise the percentage yield of the product.

i. Predict the effect of increasing the pressure (at constant temperature) on this equilibrium system. Circle your prediction and explain your reasoning.

Increase yield decrease yield no change

Reasoning:

2 marks

ii. What would happen to the yield if the product NOBr was continuously removed at constant temperature and pressure?

Increase yield decrease yield no change

Reasoning:

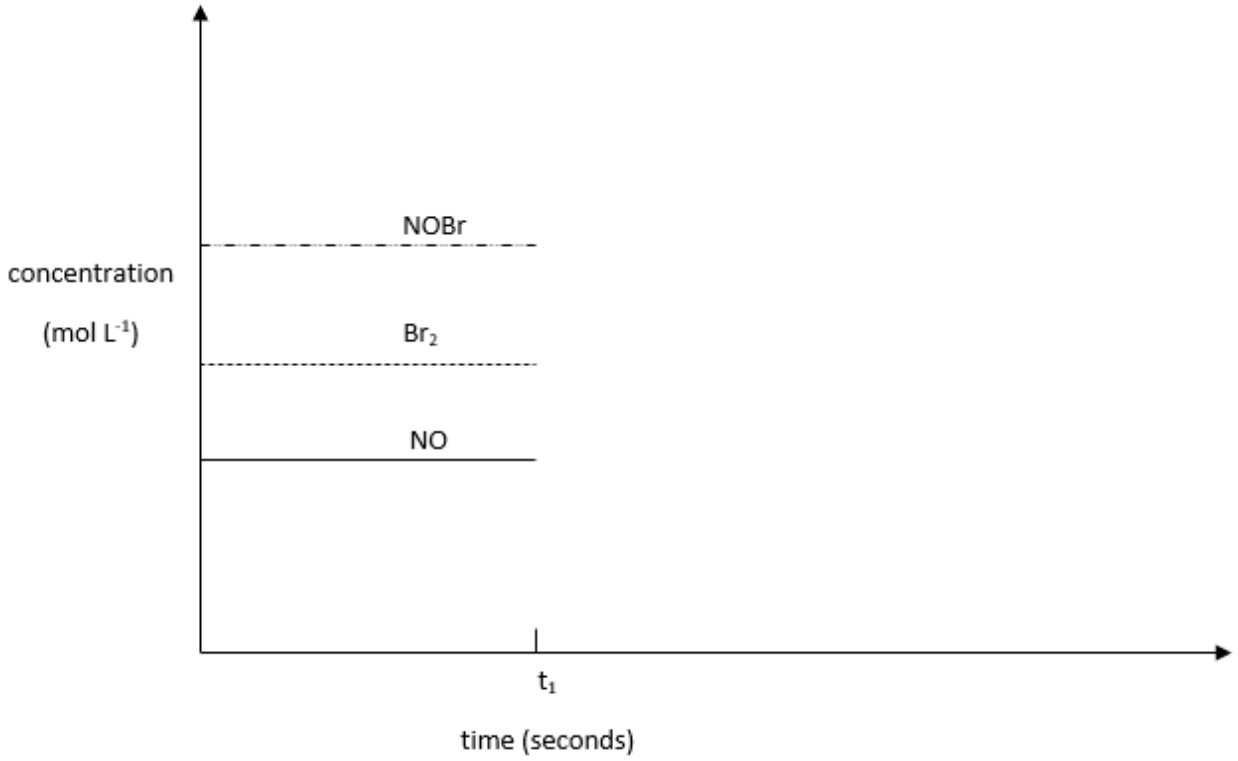
2 marks

SECTION B - Question 4 continued
TURN OVER

c. The graph below represents the concentration of the species involved in the production of NOBr at equilibrium at constant temperature. At time t_1 the temperature of the system was decreased.

Complete the graph after t_1 showing the change in concentration for each of the species.

3 marks



d. **i.** Write an expression for the equilibrium constant for this reaction.

1 mark

SECTION B - Question 4 continued
TURN OVER

ii. 1.3 mol of NO and 1.11 mol of Br_2 was placed in a 2.00 L vessel at 700^oC. When equilibrium was achieved, 0.1 mol of NOBr was present. Calculate the value of the equilibrium constant at this temperature.

3 marks

Question 5 (10 marks)

In cars, a lead-acid battery provides the electricity required to start the car by igniting the engine. Once the engine is running the battery is recharged. Car batteries are an example of secondary cells.

The overall equation during discharge of the battery is shown below.

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

a. Write down the half equation for the reaction occurring at the anode during discharge of the battery.

1 mark

b. Identify the oxidising agent during discharging. Use oxidation numbers to justify your answer.

2 marks

c. Write down the half equation for the reaction occurring at the negative electrode during recharging.

1 mark

SECTION B - Question 5 continued

TURN OVER

d. Describe one similarity between a cell that is discharging and one that is recharging.

1 mark

e. Describe one difference between a cell that is discharging and one that is recharging.

1 mark

f. What feature of a lead-acid cell allows it to act as a secondary cell?

1 mark

g. During the recharging of the battery, the pH changes and this can be used to determine how "flat" a car battery is. Explain how the pH changes when a lead-acid battery is recharged.

2 marks

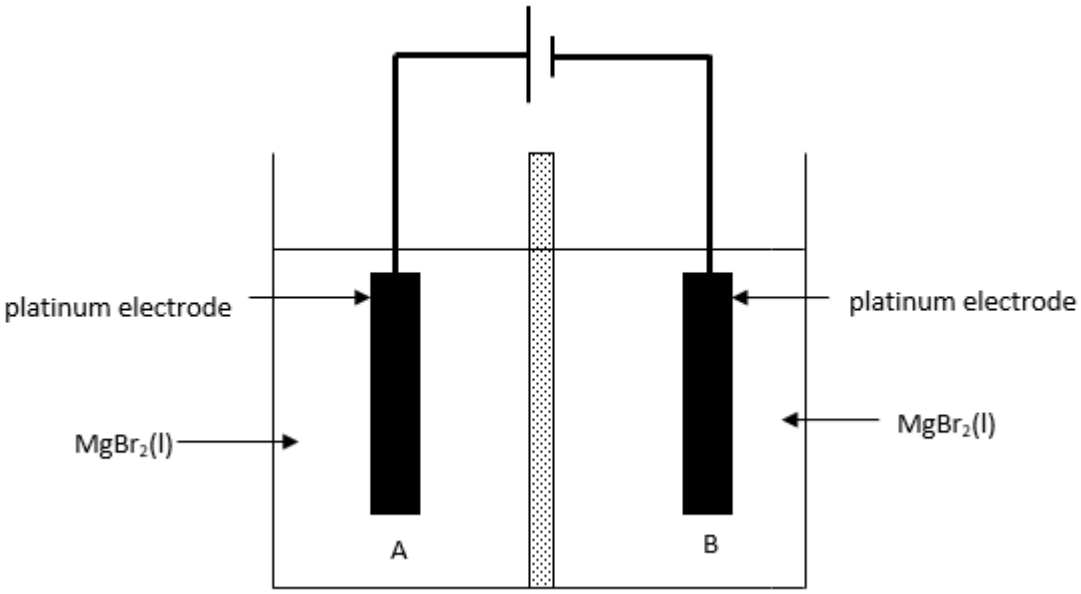
h. The voltage supplied by a lead-acid cell is 12V. What voltage should be used to recharge the battery?

1 mark

SECTION B – continued
TURN OVER

Question 6 (13 marks)

The diagram below shows an electrolytic cell used to produce magnesium by electrolysis of molten magnesium bromide.



a. Identify which electrode (A or B) is the anode.

_____

1 mark

b. What would you observe at

i. electrode A?

_____

1 mark

ii. electrode B?

_____

1 mark

SECTION B - Question 6 continued
TURN OVER

c. Write ionic equations for the two half reactions occurring at each electrode:

i. At electrode A:

ii. At electrode B:

2 marks

d. How long (in minutes) would it take to produce 1.0 g of metal if a current of 1.62 A is passed through this cell?

4 marks

e. This cell would not work if $MgBr_2(l)$ were replaced with an aqueous solution of 1.0 M $MgBr_2$. Explain how this cell would differ and why using a relevant balanced equation.

4 marks

END OF QUESTION AND ANSWER BOOK