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2011 Trial Examination

STUDENT NUMBER

Figures									Letter
Words									

CHEMISTRY

Unit 4 – Written examination 2

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

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	8	8	71
			Total 91

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

Materials supplied
- Question and answer book of 16 pages.

Instructions
- Print your name 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 electronic communication devices into the examination room.

SECTION A – Multiple-choice questions

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.

Questions 1 and 2 refer to the following information

Methanol can be produced from the reaction between carbon monoxide gas and hydrogen gas. The equation is;

$$\mathbf{CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\ kJ\ mol^{-1}}$$

At 200 °C, the value of the equilibrium constant is 12.5 M^{-2}.

Question 1
The values of ΔH and of the equilibrium constant for the **reverse** reaction at 200 °C are, respectively,
A. -91 kJ mol^{-1} and 12.5
B. -9.4 kJ mol^{-1} and 0.08
C. +91 kJ mol^{-1} and -12.5
D. +91 kJ mol^{-1} and 0.08

Question 2
The effect of an increase in temperature and a decrease in pressure on an equilibrium mixture of the above gases will be
A. a lower yield of methanol
B. unclear as one change favours the forward reaction and the other the reverse
C. a higher yield of methanol
D. an unchanged value for K but a shift in the position of equilibrium

Question 3
Beaker A contains 10 mL of 0.1 M hydrochloric acid. Beaker B contains 1.0 L of 0.1 M hydrocyanic acid. In comparison to Beaker A, Beaker B has a
A. a greater number of H_3O^+ ions
B. lower pH because the volume of acid is much greater
C. higher pH and a lower concentration of $[H_3O^+]$
D. lower pH and a lower concentration of $[H_3O^+]$

Question 4
The pH of a solution is 12. The solution might be
A. 0.005 M $Ba(OH)_2$
B. 0.01 M $Ba(OH)_2$
C. 0.01 M HCl
D. 2.0 M NaOH

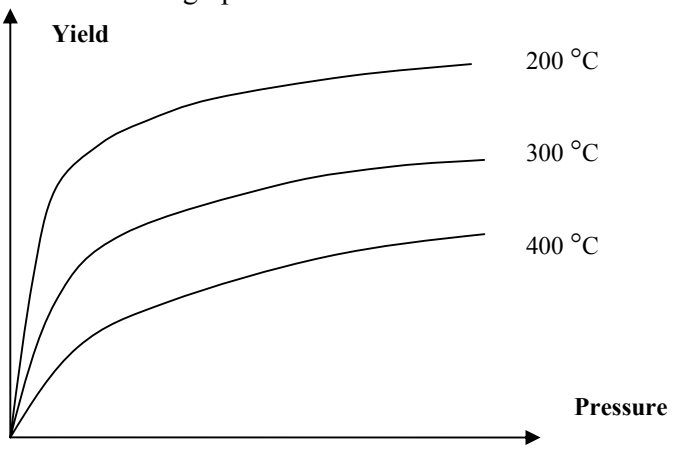
SECTION A - continued

Question 5
The temperature of a sample of distilled water is varied and the concentration of the hydroxide ion is measured at each temperature.

Temperature (°C)	$[OH^-]$ Concentration
0	3.4×10^{-8}
25	10^{-7}
50	2.35×10^{-7}

From this table it can be concluded that the
A. concentration of OH^- ions must decrease as the temperature increases
B. self-ionisation of water is an endothermic reaction
C. self-ionisation of water is an exothermic reaction
D. concentration of H_3O^+ must be decreasing as the temperature is increasing

Question 6
The yield of a reaction at a particular temperature varies as the pressure increases. The results are graphed below and then the process is repeated at two different temperatures. All results are shown on the one graph.



From the graph it can be concluded that the reaction is a reversible one that is
A. exothermic with more product molecules than reactant molecules
B. endothermic with less product molecules than reactant molecules
C. exothermic with less product molecules than reactant molecules
D. endothermic with more product molecules than reactant molecules

Question 7
Which of the following statements would apply to how various countries produce electricity from nuclear sources?

I no waste is produced
II the nuclei of small atoms join together
III uranium contains excess electrons
IV the nuclei of large atoms are split

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

SECTION A - continued
TURN OVER

Question 8
Nitrogen gas can be converted to nitrogen dioxide gas, NO_2 in a two step process. The overall equation for this process is

$$\mathbf{N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)}$$

The ΔH value for this reaction, given the following information, will be, in kJ mol^{-1},

$$\mathbf{N_2(g) + O_2(g) \rightarrow 2NO(g) \quad \Delta H = +180 \ kJ\ mol^{-1}}$$

$$\mathbf{2NO_2(g) \rightarrow 2NO(g) + O_2(g) \quad \Delta H = +112 \ kJ\ mol^{-1}}$$

A. +292
B. +68
C. -68
D. -292

Question 9
The mass of ethanol, in g, required to heat 100 mL of water from 20 °C to 60 °C will be closest to
A. 0.56
B. 1.40
C. 570
D. 1400

Question 10
Emissions produced from the combustion of coal to generate electricity include
A. SO_2 only
B. CO_2 only
C. SO_2 and CO_2 only
D. SO_2, NO and CO_2

Question 11
In many industrial processes the catalyst is heated instead of the reacting gases. The most likely reason for this is to
A. limit the opportunity for undesirable side-reactions to occur
B. increase the equilibrium constant
C. increase the reaction rate at that particular temperature
D. limit the amount of energy released by exothermic reactions

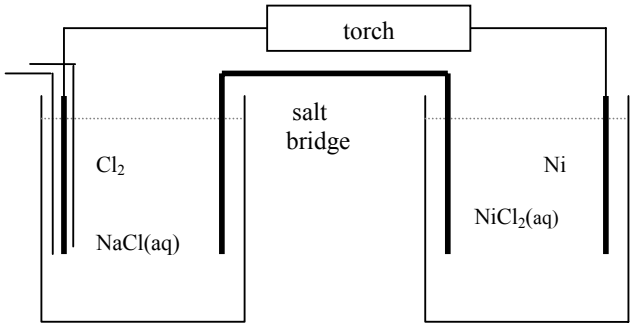
Question 12
A 0.115 mole sample of a fuel is used to heat 1 litre of water in a beaker. The water temperature increases by 20 °C. Assuming 100% efficiency of energy transfer to the water, the fuel is likely to be
A. methanol
B. ethanol
C. butane
D. glucose

SECTION A - continued

Question 13
The reaction between table sugar and sulfuric acid is a very exothermic one. The reaction rate is very slow in the initial stages of the reaction when the concentration of the sulfuric acid is very high. The reaction rate is often much higher three or four minutes after the reaction has started. A possible reason for this increased rate might be that
A. sulfuric acid is a diprotic acid
B. the energy released is significantly increasing the temperature of the reactants
C. the activation energy of the sugar molecules decreases with time
D. the pressure in the flask is increasing as the reaction proceeds

Questions 14 and 15 refer to the following information

A galvanic cell is established to power a torch, as shown below



Question 14
For this cell, the
A. electrons will flow from the chlorine to the nickel
B. nickel electrode will be the negative anode
C. concentration of nickel ions in solution will be falling
D. chlorine electrode will be the negative cathode

Question 15
For this cell, the overall equation will be
A. $Cl_2(g) + Ni^{2+}(aq) \rightarrow 2Cl^-(aq) + Ni(s)$
B. $2Cl^-(aq) + Ni(s) \rightarrow Cl_2(g) + Ni^{2+}(aq)$
C. $2Cl^-(aq) + Ni^{2+}(aq) \rightarrow Cl_2(g) + Ni(s)$
D. $Cl_2(g) + Ni(s) \rightarrow 2Cl^-(aq) + Ni^{2+}(aq)$

Question 16
Which metal cannot be obtained through electrolysis of an aqueous solution?
A. tin
B. lead
C. manganese
D. silver

Questions 17 and 18 refer to the following information

One of the types of lithium battery now in production is the lithium-iron cell. It has the same voltage as a typical alkaline cell but it copes better in high current demand uses. The overall equation for one version of this cell is

$2FeS + 4Li \rightarrow Fe + 2Li_2S$ (note: phases not shown for polymer electrolytes)

Question 17

The half equations occurring during discharge in the lithium-iron cell are

	Anode	Cathode
A.	$Li \rightarrow Li^+ + e^-$	$Fe^{2+} + 2e^- \rightarrow Fe$
B.	$Fe \rightarrow Fe^{2+} + 2e^-$	$Li \rightarrow Li^+ + e^-$
C.	$Li^+ + e^- \rightarrow Li$	$Fe \rightarrow Fe^{2+} + 2e^-$
D.	$S + 2e^- \rightarrow S^{2-}$	$Fe^{2+} + 2e^- \rightarrow Fe$

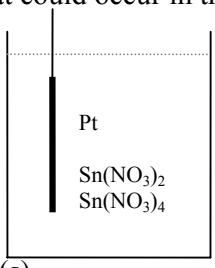
Question 18

When this cell is being recharged, the

A. reduction reaction will occur at the same electrode as during discharge
B. oxidation reaction will be at the negative electrode as an external power source is used
C. iron electrode will be connected to the positive terminal of the recharger
D. lithium electrode will be connected to the positive terminal of the recharger

Question 19

Select a half equation that could occur in the half cell shown.



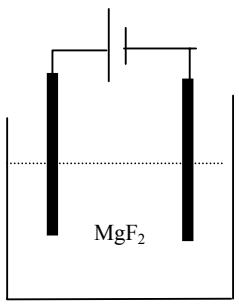
A. $Pt^{2+}(aq) + 2e^- \rightarrow Pt(s)$
B. $Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$
C. $Sn^{2+}(aq) + 2e^- \rightarrow Sn^{4+}(aq)$
D. $Sn^{2+}(aq) \rightarrow Sn^{4+}(aq) + 2e^-$

Question 20

Electrodes are placed into a molten solution of magnesium fluoride and the power supply switched on. A current of 4.0 amp flows for 24125 secs.

The number of mole of magnesium that will be produced in this cell will be

A. 0
B. 0.5
C. 1.0
D. 2.0



END OF SECTION A

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; simplified 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

Methyl orange is an indicator. It is also a weak acid with a K_a value of 2×10^{-4} M.
The chemical structure of methyl orange is complex, so its formula is represented in this question as HMe.

a. **i**. Write a balanced equation for the reaction of methyl orange with water.

_____

ii. There are many weak acids but most are not suitable for use as acid/base indicators. Explain why methyl orange is more suited as an indicator than, for example, ethanoic acid.

_____

1 + 1 = 2 marks

b. Use the balanced equation you wrote for part **a**. to explain the impact of the addition of

i. acid to methyl orange solution

_____

_____

ii. base to methyl orange solution

_____

_____

1 + 2 = 3 marks

c. When an indicator changes colour during a titration, the concentration of the indicator and its conjugate pair are almost equal. Indicators change colour over a particular pH range.

i. Write an expression for K_a for methyl orange.

_____

SECTION B – Question 1 - continued
TURN OVER

ii. Simplify your expression for K_a to reflect that the concentration of the indicator and its conjugate pair are considered equal at the transition point.

_____

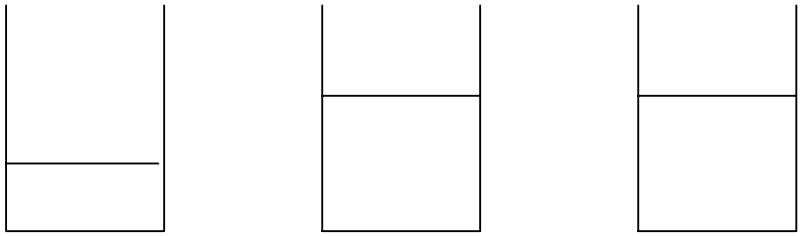
iii. Use this expression to calculate the likely pH that methyl orange will change colour at.

_____

_____

1 + 1 + 1 = 3 marks
Total 8 marks

Question 2
The contents and concentrations of three different beakers are shown in the diagram below. All beakers are at 25 °C.



Beaker A
V = 100 mL
0.01 M HCl(aq)

Beaker B
V = 200 mL
0.01 M CH_3COOH(aq)

Beaker C
V = 200 mL
0.01 M NaOH

Use your knowledge of acids and bases to complete the table below.

	Beaker A	**Beaker B**	**Beaker C**
$[H_3O^+]$			
$[OH^-]$			
K_w			
pH			

Total 8 marks

SECTION B – continued

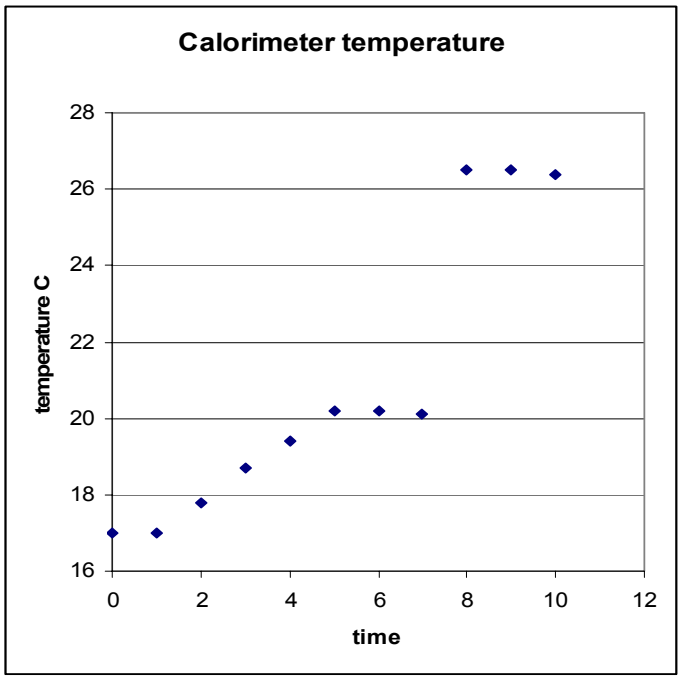
Question 3

A student investigating a chemical reaction follows the procedure outlined below:

1. Add 100 mL of distilled water to a calorimeter and allow the temperature to settle.
2. The student then passes a current of 3.60 amps through the calorimeter, measuring the temperature every minute. The potential difference is 5.80 V.
3. Add 5.00 g of anhydrous copper sulfate to the calorimeter and record the temperature change.

The reaction occurring is $\mathbf{CuSO_4(s) \rightarrow CuSO_4(aq)}$

The temperature changes during the experiment are recorded in the graph shown.



a. **i**. From the graph, how long was calibration conducted?

_____

ii. Calculate the calibration factor for the calorimeter.

_____

1 + 2 = 3 marks

b. If the experiment was repeated using the same values of voltage and current, but the time interval was double that evident in the graph, what would be the likely impact upon

i. the change in temperature during calibration. Explain your answer.

_____

ii. the calibration factor? Explain your answer.

_____

1 + 2 = 3 marks

SECTION B – Question 3 - continued

TURN OVER

c. **i**. What was the temperature change for the reaction of copper sulfate in water?

_____

ii. Calculate ΔH for the reaction of copper sulfate and water.

_____

_____

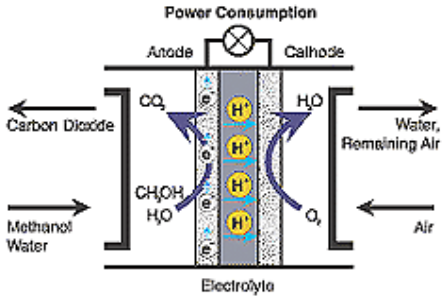
_____

1 + 3 = 4 marks
Total 10 marks

Question 4

As the price of petroleum fluctuates in the world, interest in the use of electric vehicles powered by fuel cells continues to grow. One of the simplest fuel cells to design uses hydrogen and oxygen gases as the reactants. For practical purposes however, the storage and safe use of hydrogen gas is problematical. One of the proposed solutions to this problem is the use of methanol in place of hydrogen. Such a cell is drawn below.

In this cell, hydrogen gas is still the reactant but the hydrogen is only formed when the methanol and steam react at high temperatures in the presence of a catalyst. In this way the storage problems of hydrogen are not an issue.



a. Hydrogen gas and carbon dioxide are formed from the reversible reaction between methanol and steam. This reaction is exothermic.

i. Write a balanced equation for this reaction.

_____

ii. Does high pressure favour the production of hydrogen gas? Explain your answer.

_____

iii. This reaction proceeds faster at high temperatures. Give two disadvantages with the use of high temperatures.

_____

_____

1 + 1 + 2 = 4 marks

SECTION B – Question 4 - continued

b. Once the hydrogen gas is formed it reacts with oxygen gas in an acidic electrolyte. Use the boxes provided to give the reactions occurring at the

i. **Anode**: _____

ii. **Cathode:** _____

iii. The overall equation is _____

1 + 1 + 1 = 3 marks

c. **i**. Name two waste materials formed in this cell. _____

ii. Do the waste materials you have named pose major environmental concerns?

_____

1 + 1 = 2 marks

d. Should this cell be recharged periodically? Explain your answer.

_____

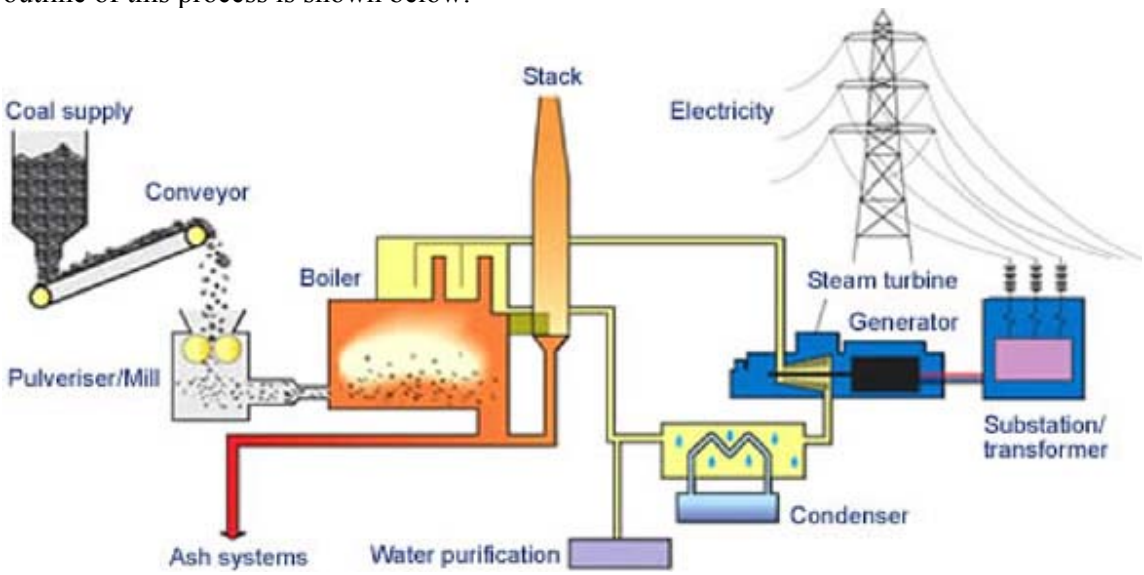
1 mark

Total 10 marks

SECTION B – continued
TURN OVER

Question 5

The majority of Australia's electrical energy is generated from the combustion of coal. An outline of this process is shown below.



a. Several gaseous products are released from the stack.

i. Name two gases produced.

_____

ii. Write a balanced equation for the formation of one of these gases.

_____

1 + 1 = 2 marks

b. What energy conversion is occurring

i. in the generator? _____

ii. in the boiler?

_____

1 + 1 = 2 marks

c. Give one reason why the coal is crushed before entering the furnace.

_____

1 mark

d. Coal is made from dead organisms. Why is it not considered to be a renewable form of energy?

_____

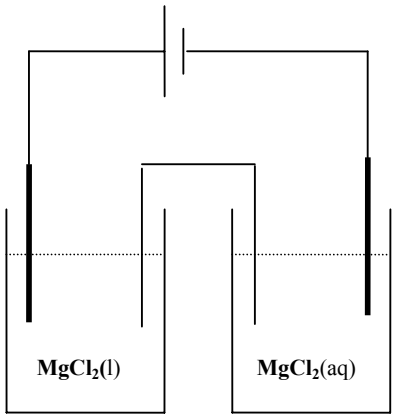
1 mark

Total 6 marks

SECTION B - continued

Question 6

Two cells are connected in series as shown below and a current is passed through the circuit. Cell A is kept at a temperature high enough to maintain a molten solution of magnesium chloride, $MgCl_2$ and cell B contains a dilute aqueous solution of the same substance.



a. Use the table below to show the half equations and products that will form in each cell.

	Cell A	**Cell B**
Anode half equation		
Cathode half equation		
Products		

6 marks

b. 4.40 mole of electrons passes through the circuit. The table below shows several species that may be products of this electrolysis. For each species, indicate how many mole will be produced from the 4.40 mole of electrons flowing through the circuit.

Species	**Number of mole produced**
magnesium	
chlorine gas	
oxygen gas	
hydrogen gas	

4 marks

SECTION B – Question 6 – continued
TURN OVER

c. What volume of gas is produced in this circuit if the gas is cooled to STP?

_____

_____

2 marks
Total 12 marks

Question 7
Carbon monoxide is a poisonous gas. Fortunately, it can react with oxygen gas to form the less toxic gas, carbon dioxide. The reaction between carbon monoxide and oxygen is a reversible one.

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) \qquad \Delta H = -546 \text{ kJ mol}^{-1}$$

a. 10 mole of carbon monoxide is added to an empty reactor.

i. When equilibrium is reached, will the amount of energy released be 2730 kJ? Explain your answer.

_____

ii. When equilibrium is reached, the amount of oxygen found to have reacted is 1.6 mole. How many mole of carbon monoxide remains?

_____

1 + 1 = 2 marks

b. At 25 °C, the value of K for this reaction is $3.4 \times 10^3 \text{ M}^{-1}$.

i. CO_2 gas is pumped into an empty room held at 25 °C. When equilibrium is reached, is the level of CO likely to be a dangerous one?

_____

ii. An engine runs for a long time in a sealed room and builds up a high level of CO gas. The engine is turned off and the gas mixture allowed to reach equilibrium. Given the high value of K, is it possible at equilibrium for the level of CO to still be dangerously high?

_____

1 + 1 = 2 marks

SECTION B – Question 7 - continued

c. An equilibrium mixture of gases has a high level of CO. List three possible changes that could be made to the system to lower the concentration of CO.

_____

_____

3 marks
Total 7 marks

Question 8
During this unit, you chose a chemical to study.
Circle the equation below that is relevant to the chemical that you studied.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$

Answer all questions below in reference to the equation that you have circled.
a. Write an expression for K for the equation you circled.

_____
1 mark

b. Explain the impact on the yield of each of the following changes
i. a decrease in temperature

_____

ii. an increase in pressure

_____

iii. the addition of a catalyst to an equilibrium mixture

_____
1 + 1 + 1 = 3 marks

c. State the temperature range and the pressure used by industry for your reaction.

_____
2 marks

d. i. Give two reasons why the use of very high pressure in chemical reactions is undesirable.

_____

_____

SECTION B – Question 8 – continued
TURN OVER

ii. Give one reason why the use of very low pressure in chemical reactions might be undesirable.

_____

2 + 1 = 3 marks

e. List one chemical hazard associated with your chosen reaction.

_____

1 mark

Total 10 marks

END OF QUESTION AND ANSWER BOOK