SYDNEY GRAMMAR SCHOOL

2017
FORM VI
TRIAL HSC EXAMINATION

Chemistry

Tuesday 8th August 8:40 a.m.

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your candidate number at the top of each page in Part B **and on the Answer Booklets**

CHECKLIST	
Each boy should have the following :	
1 Question Paper	
1 Multiple Choice Answer Sheet	
2 Five Page Booklets	

Section I Pages 3 - 22

Total marks (100)

This section has two parts, Part A and Part B

Part A
Total marks **(20)**
- Attempt Questions 1-20
- Allow about 30 minutes for this Section

Part B
Total marks **(55)**
- Attempt Questions 21-32
- Allow about 1 hour and 45 minutes for this Section

Section II Pages 23-25
Total marks **(25)**
- Attempt Question 33 in this section.
- Allow about 45 minutes for this Section

Chemistry Classes:

1. TW	2. EJS	3. CRMR	
4. AKBB	5. MRB	6. MTK	7. TW

EXAMINERS: TW / AKBB / EJS / MRB

Part A

Total marks (20)
Attempt Questions 1-20
Allow about 30 minutes for this Part

Use the multiple-choice Answer Sheet.

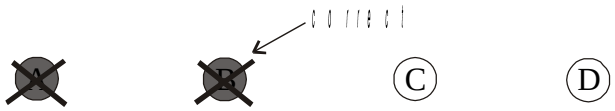
Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

Sample 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



1 Low density polyethylene contains:

(A) a low degree of branching which decreases the dispersion forces.
(B) a low degree of branching which increases the dispersion forces.
(C) a high degree of branching which decreases the dispersion forces.
(D) a high degree of branching which increases the dispersion forces.

2 Which of the following polymers is formed by a condensation reaction?

(A) styrene
(B) polyvinyl chloride
(C) polyethylene
(D) cellulose

3 The transuranic element, neptunium, was first synthesised and isolated in 1940. An incomplete equation showing the nuclear reaction is shown below.

$$^{238}_{92}\text{U} + \boldsymbol{X} \rightarrow {}^{239}_{92}\text{U} \rightarrow \boldsymbol{Y} + {}^{239}_{93}\text{Np}$$

Identify the particles shown as ***X*** and ***Y*** in the equation below.

	X	***Y***
(A)	Neutron	Beta particle
(B)	Beta particle	Neutron
(C)	Neutron	Alpha particle
(D)	Beta particle	Alpha particle

4 The permanganate ion undergoes an oxidation-reduction reaction, as shown by the reaction with zinc.

$$2\ MnO_4^-{}_{(aq)} + 5\ Zn_{(s)} + 16\ H^+{}_{(aq)} \rightarrow 5Zn^{2+}{}_{(aq)} + 2\ Mn^{2+}{}_{(aq)} + 8\ H_2O_{(l)}$$

Which row of the table shows correct information about the reaction?

	Change in oxidation state of manganese	***Role of zinc***	***Movement of electrons***
(A)	decrease of 5	reducing agent	from zinc to manganese
(B)	decrease of 5	oxidising agent	from manganese to zinc
(C)	increase of 5	reducing agent	from zinc to manganese
(D)	increase of 5	oxidising agent	from manganese to zinc

5 Which of the following pairs of chemicals could spontaneously react to form products under standard conditions?

(A) I_2 and Br^-
(B) H^+ and Cu
(C) MnO_4^- and K^+
(D) Ag^+ and Fe^{2+}

6 Which one of the following fuels releases the most energy per kg when it undergoes complete combustion?

Alkanol	Molar mass	Heat of combustion (kJ mol^{-1})
ethanol	46.1	1364
butane	58.1	2877
1-propanol	60.1	2021
hexane	86.2	4163

(A) ethanol
(B) butane
(C) 1-propanol
(D) hexane

7 Which of the following shows a model of a compound formed by the dehydration of ethanol?

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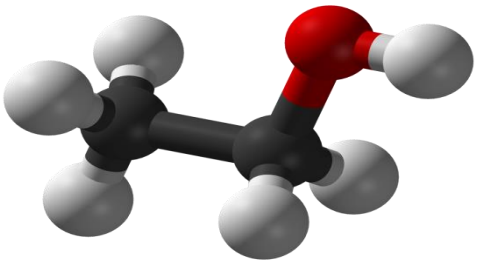

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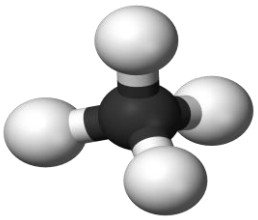
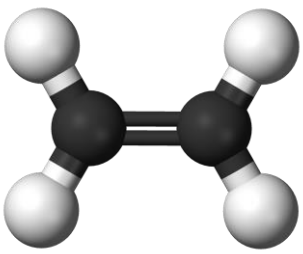
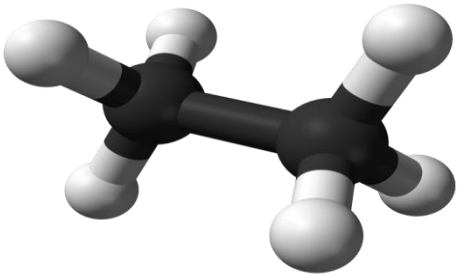


(C)


(D)


8 Which of the following pairs of ionic solids will dissolve in water and produce a precipitate upon mixing?

(A) sodium chloride and potassium nitrate
(B) copper(II) sulfate and barium nitrate
(C) lead(II) chloride and potassium nitrate
(D) calcium carbonate and barium chloride

9 Four students were asked to test a solution for the presence of a cation by using various anions. The students obtained these results:

Student	*Chloride*	*Sulfate*	*Carbonate*
A	no precipitate	precipitate	precipitate
B	precipitate	no precipitate	no precipitate
C	precipitate	no precipitate	precipitate
D	no precipitate	precipitate	no precipitate

Each student concluded that Ca^{2+} was present.

Which student had results consistent with this conclusion?

(A) *A*
(B) *B*
(C) *C*
(D) *D*

10 What is the purpose of heating the suspension of barium sulfate prior to filtration in the laboratory experiment to measure sulfate content?

(A) To volatilize any excess barium not required to precipitate the sulfate
(B) To increase the solubility of the barium sulfate so that less of it becomes trapped in the filter paper
(C) To reduce the viscosity of the water to make filtering easier.
(D) To increase the particle size of the barium sulfate

11 What mass of 1,2-dibromoethane is produced when 3.00 L of ethylene gas reacts with 16.52 g of liquid bromine at 25 °C and 100 kPa?

(A) 19.4 g
(B) 22.7 g
(C) 24.8 g
(D) 38.8 g

12 Which of the following is a **natural** source of nitrogen oxides in the environment?

(A) Car engines
(B) Burning coal
(C) Lightning
(D) Volcanic activity

13 Which of the following is a correct statement about the behaviour of a catalyst in an equilibrium system?

(A) It increases the enthalpy change of the forward reaction.
(B) It increases the enthalpy change of the reverse reaction.
(C) It decreases the activation energy of the forward reaction.
(D) It increases the activation energy of the reverse reaction.

14 A 1.0×10^{-4} mol L^{-1} solution of an acid HX has a pH of 4.0. This solution could be described as a:

(A) concentrated solution of a weak acid
(B) concentrated solution of a strong acid
(C) dilute solution of a weak acid
(D) dilute solution of a strong acid

15 A solution of hydrochloric acid had pH 3.5. If 10.00 mL of this solution was diluted with 990.0 mL of deionised water, what would be the pH of the diluted solution?

(A) 1.5
(B) 2.5
(C) 4.5
(D) 5.5

16 A solution has pH of 10. Which of the following correctly gives the concentrations of H_3O^+ and OH^-?

	$[H_3O^+]$ (mol L^{-1})	$[OH^-]$ (mol L^{-1})
(A)	1×10^{4}	1×10^{-10}
(B)	1×10^{-4}	1×10^{-10}
(C)	1×10^{-10}	1×10^{-4}
(D)	1×10^{-10}	1×10^{4}

17 Which of the following is a conjugate acid-base pair from the following reaction?

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

(A) HNO_3 and H_2SO_4
(B) $H_2NO_3^+$ and HNO_3
(C) HNO_3 and HSO_4^-
(D) $H_2NO_3^+$ and HSO_4^-

18 In a titration, a student found that an average of 26.55 mL of standardised NaOH, added from a burette, was required to neutralise 25.00 mL of an unknown acetic acid solution that had been pipetted into a conical flask. He then calculated the concentration of the acetic acid solution to be 0.7881 M.

After completing the titrations and his calculation, the student realised that he had mistakenly rinsed the conical flask with the acetic acid solution before and after each titration.

What implications would this mistake have on the actual value of the acetic acid concentration?

(A) The actual concentration is less than 0.7881 M
(B) The actual concentration is exactly 0.7881 M
(C) The actual concentration is greater than 0.7881 M
(D) It is not possible to determine whether the mistake would have any effect on the concentration.

19 Which compound will dissolve in water to give a pH greater than 7?

(A) NaCl
(B) Na_2CO_3
(C) NH_4NO_3
(D) SO_2

20 Which of the following mixtures could be used as a buffer solution?

(A) 1.0 L of 0.10 M ethanoic acid and 1.0 L of 0.10 M sodium hydroxide
(B) 1.0 L of 0.10 M ethanoic acid and 1.0 L of 0.10 M ethanol
(C) 1.0 L of 0.10 M hydrochloric acid and 1.0 L of 0.10 M sodium hydroxide
(D) 1.0 L of 0.10 M ethanoic acid and 1.0 L of 0.10 M sodium ethanoate

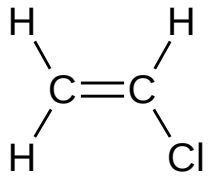
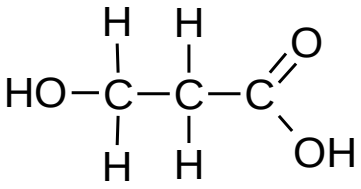
Part B

Total marks (55)
Attempt ALL Questions
Allow about 1 hour and 45 minutes for this Part

Answer the questions in the spaces provided
Show **all** relevant working in questions involving calculations

Question 21 (5 marks) **Marks**

The table below shows the structural formula of two monomers, labelled A and B.

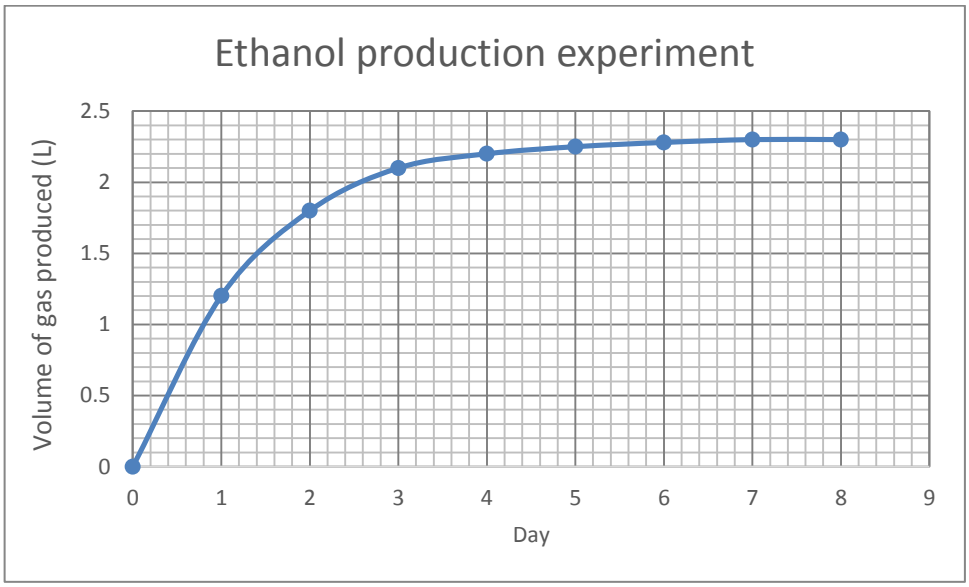
Monomer	Structural formula
A	
B	

Compare the polymerisation reactions of monomers A and B, using appropriate equations to support your answer.

5

Question 22 (6 marks) **Marks**

Ethanol can be readily made from renewable sources such as glucose. A pupil conducted an experiment to produce ethanol from glucose during which a gas was evolved. The graph below shows the volume of gas produced during the reaction over 8 days. The reaction was carried out at 25 °C and 100 kPa.



(a) Name the process used to produce ethanol from glucose.

_____ **1**

(b) Apart from temperature, identify two conditions that would promote the production of ethanol from glucose.

_____ **2**

_____

_____

_____

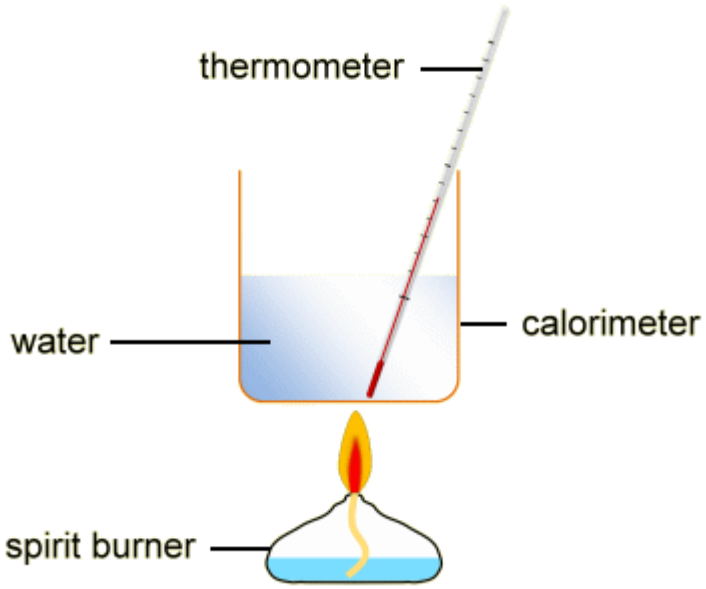
Question 22 continued on next page.

Question 22 continued. **Marks**

(c) Assuming that all of the gas produced comes from the fermentation of glucose, calculate the mass of glucose that reacted over the 8 days. **3**

Question 23 (4 marks) **Marks**

The diagram below shows the equipment used in a school laboratory for comparing the heat of combustion for a number of different liquid alkanols.

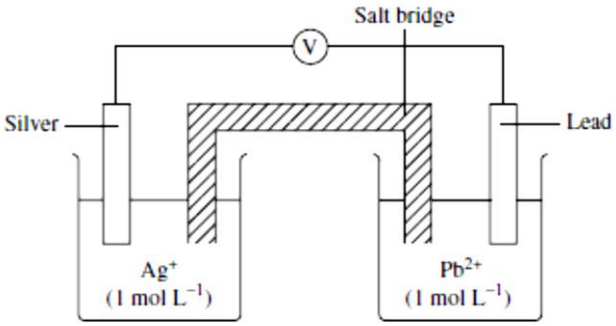


(a) Discuss the validity of using this equipment to qualitatively compare the heat of combustion of different liquid alkanols. **1**

(b) A pupil used this equipment to heat 250.0 g of water. The mass of the spirit burner, which contained ethanol, decreased from 296.52 g to 295.95 g. Given the heat of combustion of ethanol is 1367 kJ mol^{-1}, calculate the maximum possible change in the temperature of the water. **3**

Question 24 (5 marks) **Marks**

The diagram shows a galvanic cell.



(a) On the diagram, clearly identify the anode and the direction of electron flow in this cell.

2

(b) Identify ONE observation (apart from the voltage reading) that you would make after the cell had been operating for 20 minutes.

_____ **1**

_____

(c) Calculate $E^{\ominus}$ for this cell.

_____ **1**

_____

(d) Identify a suitable salt for the salt bridge.

_____ **1**

_____

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Question 25 (2 marks) **Marks**

Explain why is it important to monitor the pressure of the reaction vessel during the Haber Process.

2

Question 26 (1 marks)

Write a balanced chemical equation for the incomplete combustion of 1-pentanol ($C_5H_{11}OH$) in oxygen.

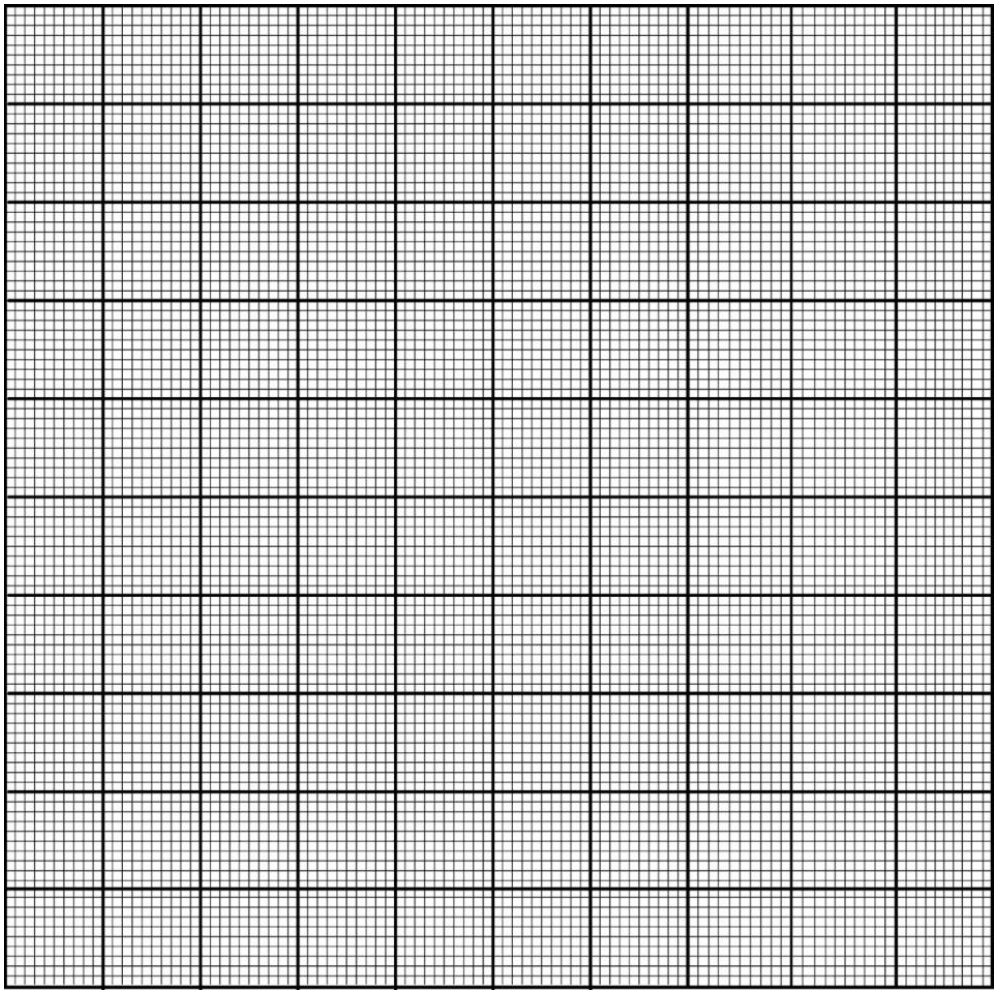
1

Question 27 (6 marks) **Marks**

A series of solutions containing calcium ions at known concentrations is prepared and analysed for calcium by AAS. The AAS results are recorded in the table below.

(a) Graph these results. **3**

	Standard 1	Standard 2	Standard 3	Standard 4	Unknown
Absorbance	0.11	0.19	0.27	0.37	0.23
Concentration (ppm)	9.5	16.5	24.0	33.0	



Question 27 continued on next page.

Question 27 continued. **Marks**

A 25.0 mL sample of creek water is appropriately processed and then diluted to 100 mL. The diluted sample was then analysed for calcium by AAS in the same way as previously described, giving an absorbance of 0.23.

(b) Determine the concentration (in mol L^{-1}) of the calcium ions in the sample of creek water. **3**

Question 28 (3 marks)

A student wanted to prepare 1-propyl ethanoate.

Outline how the student could prepare this compound in a school laboratory. **3**

Question 29 (3 marks)

A solid sample was known to contain either sodium carbonate, or a mixture of sodium carbonate and sodium phosphate.

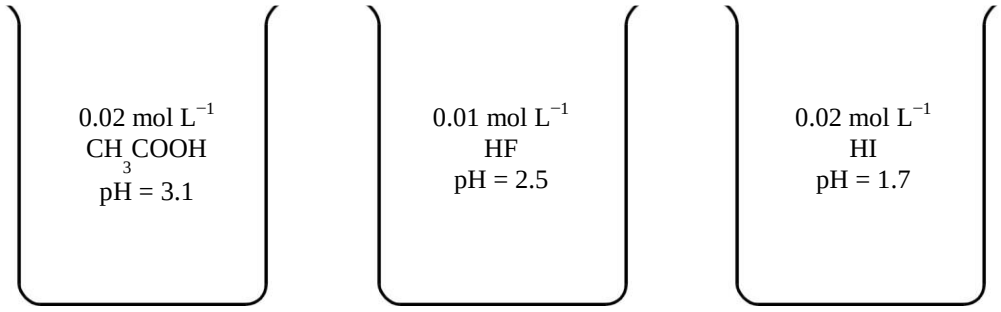
Describe how you could identify whether or not sodium phosphate is present in the solid sample, given the following reagents:

- deionised water
- barium hydroxide
- magnesium chloride
- sulfuric acid
- nitric acid.

3

Question 30 (4 marks) **Marks**

The pH of three acidic solutions was measured.



Place the acids in order from strongest to weakest, and explain your answer with reference to appropriate chemical equations.

4

Question 31 (9 marks) **Marks**

Magnesium deficiency is commonly treated with supplements containing magnesium oxide.

A tablet for the treatment of magnesium deficiency was weighed and found to have mass 1.103 g. The tablet was crushed, and 25.00 mL of 4.150 mol L^{-1} hydrochloric acid was added to the tablet. The mixture was then filtered to remove insoluble materials, and the filtrate diluted to 250.0 mL in a volumetric flask. 25.00 mL aliquots of the solution were titrated with 0.2347 mol L^{-1} sodium hydroxide. Four titres were obtained; 32.15 mL, 30.20 mL, 30.10 mL, and 30.25 mL.

(a) Write a balanced chemical equation for the reaction of magnesium oxide with hydrochloric acid.

1

(b) Write a balanced chemical equation for the titration reaction.

1

(c) Calculate the chemical amount (in mol) of hydrochloric acid that was added to the crushed tablet.

2

Question 31 continued on next page.

Question 31 continued. **Marks**

(d) Calculate the percentage by mass of magnesium oxide in the original tablet.

5

Question 32 (7 marks) **Marks**

"The modern world would be inconceivable without catalysts. The development of chemical products is only made technically, economically, and ecologically possible by using specific catalysts."

Evaluate this statement with reference to the Haber process and one other chemical process that you have studied this year in the Core modules (i.e. Production of Materials, The Acidic Environment and Chemical Monitoring and Management, **NOT** Industrial Chemistry).

7

Section II

25 marks
Attempt question 33 in this section.
Allow about 45 minutes for this section.

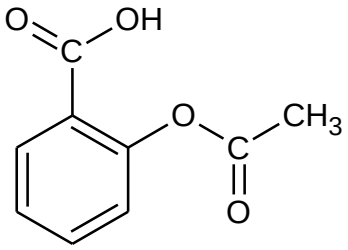
Answer the question in a **writing booklet**. Extra writing booklets are available.

Show **all** relevant working in questions involving calculations.

Question 33 — Industrial Chemistry (25 marks)

Answer parts (a) and (b) in a Writing Booklet.

(a) Aspirin is a naturally occurring compound, extracted from the bark of willow trees. Its common chemical name is acetylsalicylic acid and it has the following chemical structure:



Its use as an analgesic has been known about for millennia but demand always outstripped supply until a synthetic way to manufacture it was found.

(i) Name another natural product in short supply that is not a fossil fuel, and outline the development of an identified replacement material. **3**

Acetylsalicylic acid is a weak acid. It reacts with water according to the following balanced chemical equation, where HA represents acetylsalicylic acid:

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

(ii) With reference to the structural formula of acetylsalicylic acid given above, draw the structure of its conjugate base, A^-. **1**

(iii) Write the equilibrium constant expression for the equation above. **1**

(iv) At 25 °C the equilibrium constant for the ionisation of pure acetylsalicylic acid is 2.8×10^{-4}. If the concentration of molecular acetylsalicylic acid is 0.15 M at equilibrium, calculate the concentration of the hydrogen ions in the solution. **3**

(v) At 30 °C the equilibrium constant for the ionisation of acetylsalicylic acid is less than 2.8×10^{-4}. What does this tell you about ΔH for this reaction? Justify your answer. **2**

(b) Sulfuric acid is often said to be the most commonly used industrial chemical.

(i) The starting point for sulfuric acid manufacture is extraction of sulfur from the lithosphere. Explain how the properties of sulfur assist in its extraction. **3**

(ii) A later stage in the manufacture of sulfuric acid depends on the production of a $H_2S_2O_7$ intermediary. Name this intermediary and explain the significance of its production in the manufacture of sulfuric acid. **3**

Start a new Writing Booklet to answer parts (c) and (d).

(c) The Solvay Process has many industrial applications.

(i) Write an overall equation for the Solvay Process. **1**

(ii) Identify the process by which sodium hydrogen carbonate is removed from the mixture produced in the reaction vessel. **1**

(d) Industrial saponification is dependent on the use of caustic soda (NaOH). Discuss the environmental issues associated with the manufacture of soap when the caustic soda used in its manufacture is produced from a flowing mercury cathode cell. **7**

1 Low density polyethylene contains:

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(B) a low degree of branching which increases the dispersion forces.
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Identify the particles shown as ***X*** and ***Y*** in the equation below.

	X	***Y***
(A)	**Neutron**	**Beta particle**
(B)	Beta particle	Neutron
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Which row of the table shows correct information about the reaction?

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(B)	decrease of 5	oxidising agent	from manganese to zinc
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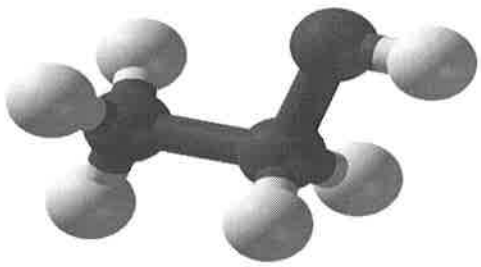

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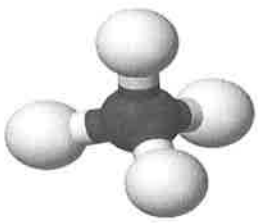
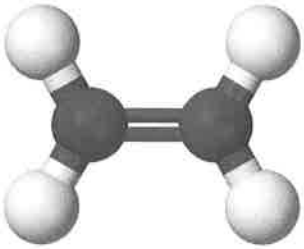
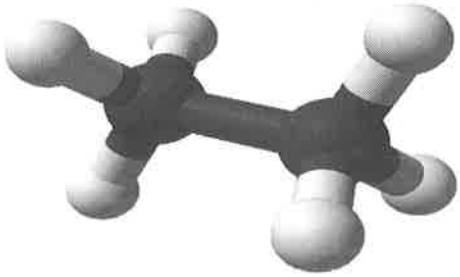


(C)



(D)



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(D) It increases the activation energy of the reverse reaction.

14 A 1.0×10^{-4} mol L^{-1} solution of an acid HX has a pH of 4.0. This solution could be described as a:

(A) concentrated solution of a weak acid
(B) concentrated solution of a strong acid
(C) dilute solution of a weak acid
(D) **dilute solution of a strong acid**

15 A solution of hydrochloric acid had pH 3.5. If 10.00 mL of this solution was diluted with 990.0 mL of deionised water, what would be the pH of the diluted solution?

(A) 1.5
(B) 2.5
(C) 4.5
(D) **5.5**

16 A solution has pH of 10. Which of the following correctly gives the concentrations of H_3O^+ and OH^-?

	$[H_3O^+]$ (mol L^{-1})	$[OH^-]$ (mol L^{-1})
(A)	1×10^{4}	1×10^{-10}
(B)	1×10^{-4}	1×10^{-10}
(C)	1×10^{-10}	1×10^{-4}
(D)	1×10^{-10}	1×10^{4}

17 Which of the following is a conjugate acid-base pair from the following reaction?

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

(A) HNO_3 and H_2SO_4
(B) $H_2NO_3^+$ and HNO_3
(C) HNO_3 and HSO_4^-
(D) $H_2NO_3^+$ and HSO_4^-

18 In a titration, a student found that an average of 26.55 mL of standardised NaOH, added from a burette, was required to neutralise 25.00 mL of an unknown acetic acid solution that had been pipetted into a conical flask. He then calculated the concentration of the acetic acid solution to be 0.7881 M.

After completing the titrations and his calculation, the student realised that he had mistakenly rinsed the conical flask with the acetic acid solution before and after each titration.

What implications would this mistake have on the actual value of the acetic acid concentration?

(A) The actual concentration is less than 0.7881 M
(B) The actual concentration is exactly 0.7881 M
(C) The actual concentration is greater than 0.7881 M
(D) It is not possible to determine whether the mistake would have any effect on the concentration.

19 Which compound will dissolve in water to give a pH greater than 7?

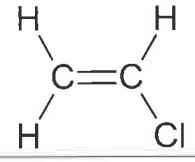
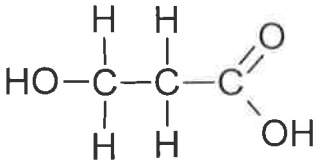
(A) NaCl
(B) Na_2CO_3
(C) NH_4NO_3
(D) SO_2

20 Which of the following mixtures could be used as a buffer solution?

(A) 1.0 L of 0.10 M ethanoic acid and 1.0 L of 0.10 M sodium hydroxide
(B) 1.0 L of 0.10 M ethanoic acid and 1.0 L of 0.10 M ethanol
(C) 1.0 L of 0.10 M hydrochloric acid and 1.0 L of 0.10 M sodium hydroxide
(D) **1.0 L of 0.10 M ethanoic acid and 1.0 L of 0.10 M sodium ethanoate**

Question 21 (5 marks) **Marks**

The table below shows the structural formula of two monomers, labelled A and B.

Monomer	Structural formula
A	
B	

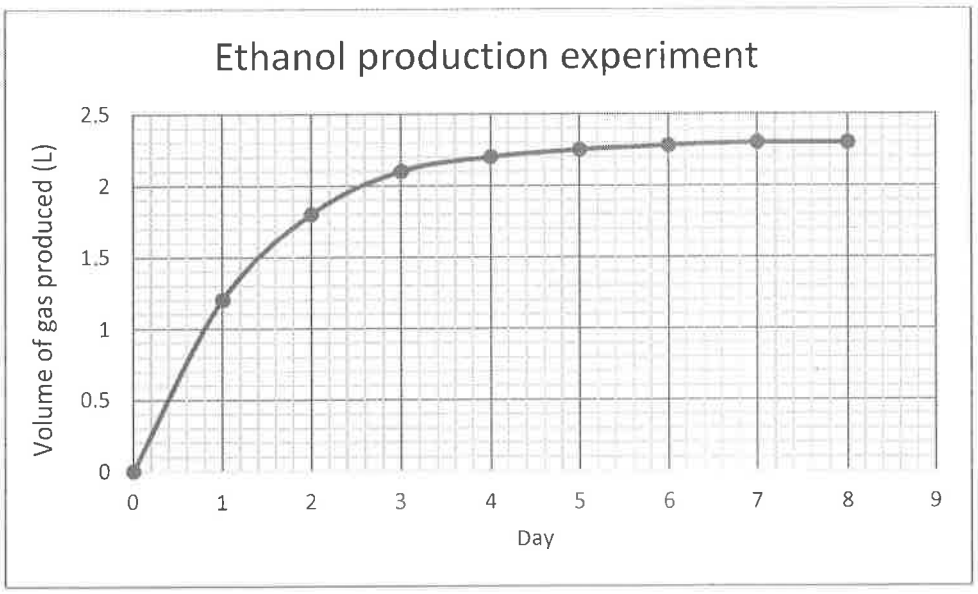
Compare the polymerisation reactions of monomers A and B, using appropriate equations to support your answer.

Marks	Requirement
5	• Clear, logical comparison the two types of polymerisation (and not just a paragraph about each). • Discusses addition polymerisation for A and condensation polymerisation for B. • Provides two relevant equations. • Provides two points of difference or similarity.
4	• As per 5 marks – but missing one point.
3	• Discusses addition polymerisation for A and condensation polymerisation for B. • Provides one relevant equation. • Provides one point of difference or similarity.
2	• Mentions addition polymerisation for A and condensation polymerisation for B. • Provides one relevant equation. OR • Provides one point of difference or similarity.
1	• Provides any relevant point about polymerisation of either monomer.

Question was marked holistically – but codes were used to explain where boys' answers could be improved:
C – no comparison – just 2 x paragraphs
D1/2 – differences not clear
E1/E2 – equations inaccurate

Question 22 (6 marks) **Marks**

Ethanol can be readily made from renewable sources such as glucose. A pupil conducted an experiment to produce ethanol from glucose during which a gas was evolved. The graph below shows the volume of gas produced during the reaction over 8 days. The reaction was carried out at 25 °C and 100 kPa.



(a) Name the process used to produce ethanol from glucose.

Fermentation ***1***

- *Inadvertently mentioned in Part c.*

(b) Apart from temperature, identify two conditions that would promote the production of ethanol from glucose.

Any 2 valid options

e.g. aqueous solution, presence of yeast, anaerobic conditions, slightly acidic, yeast nutrients.

Did not pay pressure, add more glucose ***2***

Question 22 continued on next page.

Question 22 continued. **Marks**

(c) Assuming that all of the gas produced comes from the fermentation of glucose, calculate the mass of glucose that reacted over the 8 days.

3 marks – correctly calculates 8.4 g of glucose **3**
2 marks – misses 1 step
1 mark – any correct step that it is properly set out identifying quantity calculated or read from graph.

Sample Answer

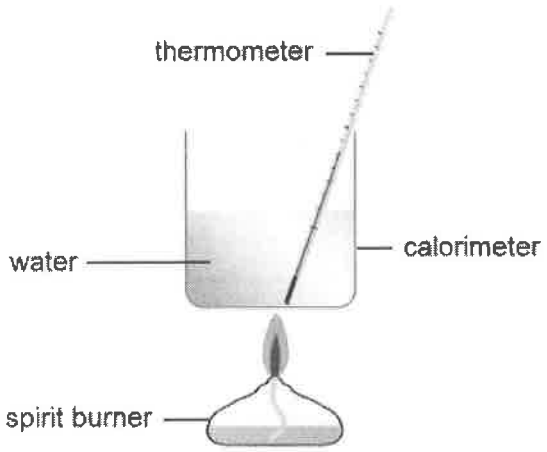
From graph,

$V(CO_2)$ at completion of reaction = 2.3 L
$n(CO_2) = 2.3 / 24.79$
n(glucose) = ½ x $n(CO_2)$ from equation
m(glucose) = n x MW
= ½ x 2.3 / 24.79 x (6 x 12.01+ 6 x 16 + 12 x 1.008)
= 8.4 g

Many boys got the formula for glucose wrong.
Some boys added up the volume of gas per day.

Question 23 (4 marks) **Marks**

The diagram below shows the equipment used in a school laboratory for comparing the heat of combustion for a number of different liquid alkanols.



(a) Discuss the validity of using this equipment to qualitatively compare the heat of combustion of different liquid alkanols.

1

(b) A pupil used this equipment to heat 250.0 g of water. The mass of the spirit burner, which contained ethanol, decreased from 296.52 g to 295.95 g. Given the heat of combustion of ethanol is 1367 kJ mol^{-1}, calculate the maximum possible change in the temperature of the water.

3 marks – correctly calculates 16.2 3
2 marks – misses 1 step
1 mark – any correct step that it is properly set out identifying quantity calculated

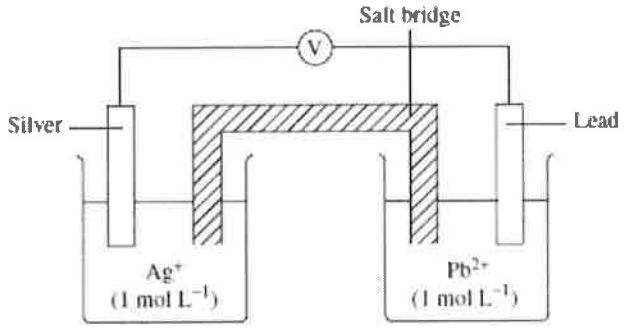
Sample Answer

m(ethanol) = 296.52 – 295.95 = 0.57 g
n(ethanol) = 0.57 / 46.068
q = ΔH x n = 16.914 kJ
q = mCΔT
16914 = 0.25 x 4.18 x ΔT
ΔT = 16.2 K

- *Many boys got the formula for ethanol wrong, saying it had 5 x H.*
- *Some boys substituted 0.57 g as mass of water.*

Question 24 (5 marks) **Marks**

The diagram shows a galvanic cell.



(a) On the diagram, clearly identify the anode and the direction of electron flow in this cell.

2 marks - Labels the lead electrode as anode and electron flow from anode to cathode
1 mark – Labels both back to front OR labels one correctly **2**

- *Note the metal electrode MUST be identified as anode – answers that just pointed to the RHS or beaker were not awarded marks.*

(b) Identify ONE observation (apart from the voltage reading) that you would make after the cell had been operating for 20 minutes.

1 mark – Identifies either silver deposits on silver electrode or lead metal loses mass

(c) Calculate $E^{\ominus}$ for this cell.

0.8 + 0.13 = 0.93 V **1**

(d) Identify a suitable salt for the salt bridge.

Any valid salt that will not precipitate e.g. potassium nitrate *1*

Question 25 (2 marks) **Marks**

Explain why is it important to monitor the pressure of the reaction vessel during the Haber Process.

1 Mark If pressure is too low then yield and reaction rate too slow / low.

1 Mark If pressure is too high the process becomes unsafe due to equipment failure.

Note cost of equipment is not a monitoring issue it is a design issue.

Question 26 (1 marks)

Write a balanced chemical equation for the incomplete combustion of 1-pentanol ($C_5H_{11}OH$) in oxygen.

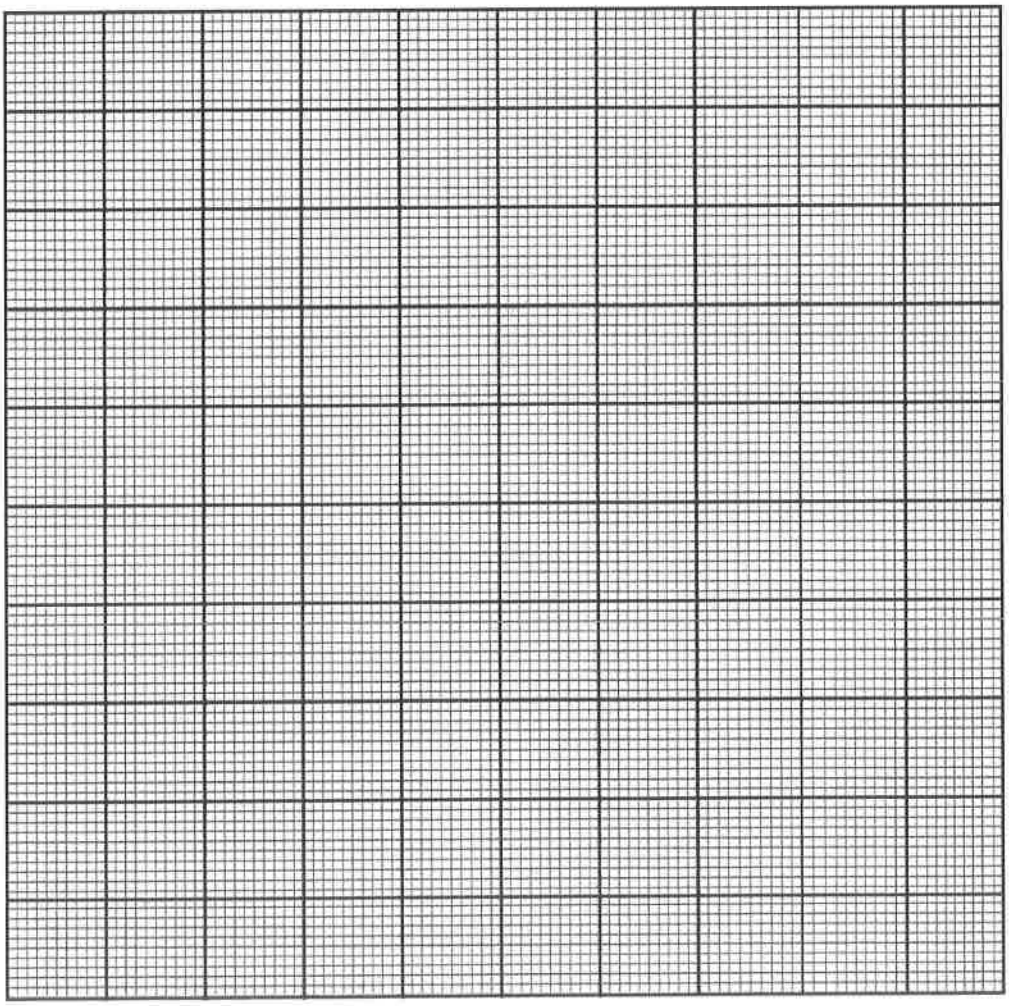
1 Mark Many correct answers. **1**

Question 27 (6 marks) **Marks**

A series of solutions containing calcium ions at known concentrations is prepared and analysed for calcium by AAS. The AAS results are recorded in the table below.

(a) Graph these results. **3**

	Standard 1	Standard 2	Standard 3	Standard 4	Unknown
Absorbance	0.11	0.19	0.27	0.37	0.23
Concentration (ppm)	9.5	16.5	24.0	33.0	



1 Mark Axes labelled with linear scale and correct unit

Question 27 continued on next page.

1 Mark Points correctly plotted. Interestingly, this is where most boys lost their marks. "Close enough" is not good enough. The points lie on a line!

Question 27 continued. **Marks**

A 25.0 mL sample of creek water is appropriately processed and then diluted to 100 mL. The diluted sample was then analysed for calcium by AAS in the same way as previously described, giving an absorbance of 0.23.

(b) Determine the concentration (in mol L^{-1}) of the calcium ions in the sample of creek water.

20-22 ppm

(1 Mark - Value from graph - typically 21 mg/L

(1 Mark - 4x multiplier working back from 100mL diluted sample to concentrated 25 mL sample (eg 21 x 4 = 84 ppm)

(1 Mark - correct conc of sample

$[Ca^{2+}] = \frac{84}{40.08} = 2.0 \times 10^{-3}$ mol L^{-1} (2 sig fig)

Question 28 (3 marks)

A student wanted to prepare 1-propyl ethanoate.

Outline how the student could prepare this compound in a school laboratory.

(1 Mark Identifying materials. eg conc. H_2SO_4, 1-propanol, ethanoic acid, 18M H_2SO_4.

(1 Mark Identifying sensible quantities eg 20mL, 20mL, 10 drops → 5mL

(1 Mark Reflux for defined time (30mins → 2h)

Question 29 (3 marks)

A solid sample was known to contain either sodium carbonate, or a mixture of sodium carbonate and sodium phosphate.

Describe how you could identify whether or not sodium phosphate is present in the solid sample, given the following reagents:

- deionised water
- barium hydroxide
- magnesium chloride
- sulfuric acid
- nitric acid.

Dilute solutions / dissolve solids.

action 1 Mark (1) Add HNO_3 (aq) until the bubbling ceases. 3

action 1 Mark (2) Add "excess" $Ba(OH)_2$.

description 1 Mark

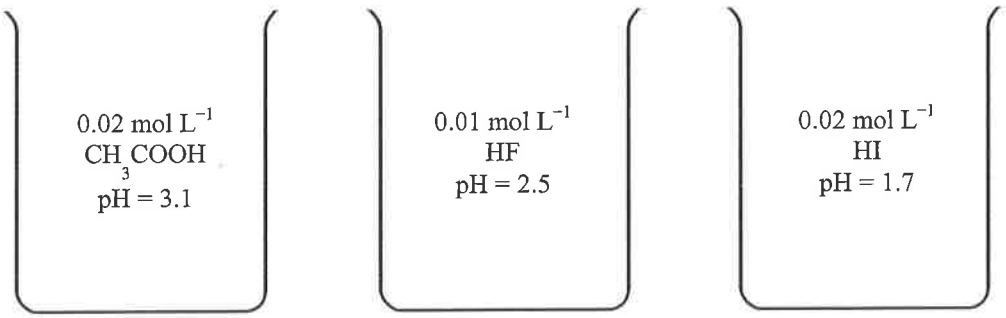
(a) If white ppt forms then ~~PO_4^{3-}~~ sodium phosphate was present

(b) If no white ppt forms then sodium phosphate was not present.

Candidate number CRIB EJS

Question 30 (4 marks) **Marks**

The pH of three acidic solutions was measured.



Place the acids in order from strongest to weakest, and explain your answer with reference to appropriate chemical equations.

4

(1) HI, HF, CH_3COOH

(1) explanation HI strong as 100% ionised

(1) explanation CH_3COOH weaker than HF

(1) equations (at least one for strong ionisation & one for weak)

Question 31 (9 marks) **Marks**

Magnesium deficiency is commonly treated with supplements containing magnesium oxide.

A tablet for the treatment of magnesium deficiency was weighed and found to have mass 1.103 g. The tablet was crushed, and 25.00 mL of 4.150 mol L^{-1} hydrochloric acid was added to the tablet. The mixture was then filtered to remove insoluble materials, and the filtrate diluted to 250.0 mL in a volumetric flask. 25.00 mL aliquots of the solution were titrated with 0.2347 mol L^{-1} sodium hydroxide. Four titres were obtained; 32.15 mL, 30.20 mL, 30.10 mL, and 30.25 mL.

(a) Write a balanced chemical equation for the reaction of magnesium oxide with hydrochloric acid. **1**

$MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)}$

(b) Write a balanced chemical equation for the titration reaction. **1**

* $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

(c) Calculate the chemical amount (in mol) of hydrochloric acid that was added to the crushed tablet. **2**

$n(HCl) = C \times V = 4.150 \times 0.02500$

$= 0.1038$ mol

① numerical answer

① sig figs (4)

Question 31 continued on next page.

* A precipitate of $Mg(OH)_2$ will not form in an acidic solution

Question 31 continued. **Marks**

(d) Calculate the percentage by mass of magnesium oxide in the original tablet. **5**

32.15 mL outlier

$\therefore V_{av} = 0.03018$ L NaOH

(1) $n(NaOH) = 0.03018 \times 0.2347 = 0.007084$ mol

$\therefore n(HCl) = 0.007084$ mol in 25 mL

(1) $\therefore n(HCl) = 0.07084$ mol in 250mL sample

$n(HCl$ reacted ω $MgO) = 0.1038$ mol $- 0.07084$ mol

(1) $= 0.03296$ mol

$n(MgO) = \frac{1}{2} n(HCl$

$= 0.01648$ mol

$m(MgO) = 0.01648 \times (24.31 + 16)$

(1) $= 0.6643$ g

(1) $\%\ MgO = \frac{0.6643}{1.103} \times 100$

$= 60.23\%$

NOTE: boys who produced $Mg(OH)_2$ in (b) could still get 3 marks for this Q

Question 32 (7 marks) **Marks**

"The modern world would be inconceivable without catalysts. The development of chemical products is only made technically, economically, and ecologically possible by using specific catalysts."

Evaluate this statement with reference to the Haber process and one other chemical process that you have studied this year in the Core modules (i.e. Production of Materials, The Acidic Environment and Chemical Monitoring and Management, **NOT** Industrial Chemistry).

7

Question 32

Criteria	Marks
• Correctly identifies the catalyst in the Haber Process and one other relevant process • Includes relevant chemical equation for each process. • Demonstrates clear links between the use of the catalyst and the technical, economical and ecological aspects of each process. • Demonstrates understanding of how catalysts work • Outlines the importance of the reaction product/s for each process to modern society. • Makes an informed evaluation on the importance of catalysts to the modern world • Demonstrates coherent and logical progression and correct use of chemical terms.	7
• Missing one aspect of above	6
• Correctly identifies the catalyst in at least one process. • Describes chemistry for both processes and includes a relevant chemical equation at least one process. • Provides some links between the use of the catalyst and the technical, economical and ecological aspects of each process OR demonstrates understanding of how catalysts work. • Outlines the importance of the reaction product/s for each process to modern society OR makes an informed evaluation on the importance of catalysts to the modern world.	4-5
• Correctly describes chemistry of at least one relevant process. • Provides at least one link between the use of a catalyst and at least one aspect of the stated process/s (the technical, economical or ecological). • Outlines an implication for society OR provides appropriate evaluation	2-3
• Provides relevant equation OR • Identifies a relevant catalyst for Haber or another appropriate process OR • Identifies a relevant chemical concept OR • Outlines the importance of one reaction product to modern society.	1

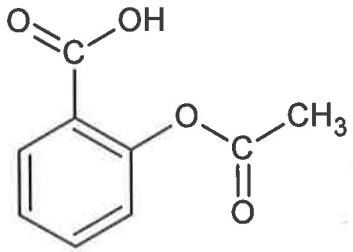
NOTE:

- It wasn't relevant to talk about the importance of the Haber process to Germany during WWI as the question asked about modern society.
- Haber Process is **not** viable without the catalyst. The reaction is impossibly slow at low temps and the yield is unviable at the temps required for reasonable reaction rate.

Question 33 — Industrial Chemistry (25 marks)

Answer parts (a) and (b) in a Writing Booklet.

(a) Aspirin is a naturally occurring compound, extracted from the bark of willow trees. Its common chemical name is acetylsalicylic acid and it has the following chemical structure:



Its use as an analgesic has been known about for millennia but demand always outstripped supply until a synthetic way to manufacture it was found.

(i) Name another natural product in short supply that is not a fossil fuel, and outline the development of an identified replacement material. **3**

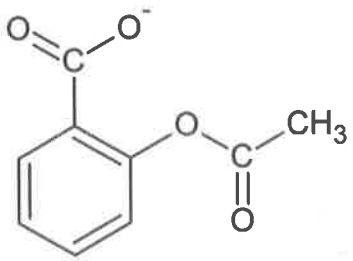
NP – Name of natural product missing
OD – Outline of development missing
RM – Replacement material missing

3 Marks	**3 items above supplied; including an outline of the chemistry involved in the development of replacement material**
2 Marks	**2 items above supplied**
1 Mark	**1 items above supplied**

Acetylsalicylic acid is a weak acid. It reacts with water according to the following balanced chemical equation, where HA represents acetylsalicylic acid:

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

(ii) With reference to the structural formula of acetylsalicylic acid given above, draw the structure of its conjugate base, A^-. **1**



(iii) Write the equilibrium constant expression for the equation above. **1**

$$K = \frac{[H^+][A^-]}{[HA]}$$

(iv) At 25 °C the equilibrium constant for the ionisation of pure acetylsalicylic acid is 2.8×10^{-4}. If the concentration of molecular acetylsalicylic acid is 0.15 M at equilibrium, calculate the concentration of the hydrogen ions in the solution. **3**

$[H^+]^2 = \mathbf{K} \times [HA]$ **1 Mark**

$= 2.8 \times 10^{-4} \times 0.15$

$\mathbf{= 4.2 \times 10^{-5}}$ **1 Mark**

$[H^+] = \sqrt{4.2 \times 10^{-5}}$
$= 6.48 \times 10^{-3}$
$\mathbf{= 6.5 \times 10^{-3}}$ **(sig figs)** **1 Mark**

(v) At 30 °C the equilibrium constant for the ionisation of acetylsalicylic acid is less than 2.8×10^{-4}. What does this tell you about ΔH for this reaction? Justify your answer. **2**

@ 30°C $K < 2.8 \times 10^{-4}$

- numerator must have decreased and/or denominator increased i.e. **equilibrium shifted left**

1 Mark

- increased heat favours reverse reaction; **forward reaction is exothermic**

1 Mark

(b) Sulfuric acid is often said to be the most commonly used industrial chemical.

(i) The starting point for sulfuric acid manufacture is extraction of sulfur from the lithosphere. Explain how the properties of sulfur assist in its extraction. **3**

Marks awarded for two relevant properties (P_1 and P_2)

eg

***Sulfur's relatively low melting point (115 °C)** means that the superheated water could easily melt it.

***Sulfur is relatively inert/insoluble** (ie doesn't dissolve in water or react with air upon extraction)

NB – liquid sulfur's density is higher than that of water. That is why air needs to be injected in order to froth the sulfur /(water mixture) and lower the density. Thus a mark for low density of sulfur was only awarded if linked to froth extraction.

2 Marks

Outline (O) of Frasch process

1 Mark

(ii) A later stage in the manufacture of sulfuric acid depends on the production of a $H_2S_2O_7$ intermediary. Name this intermediary and explain the significance of its production in the manufacture of sulfuric acid. **3**

3 Marks	Oleum stated **PLUS** 2 oleum equations **PLUS** significance of production (i.e. process used to prevent formation of fine mist of H_2SO_4 when SO_3 added directly to water)
2 Marks	2 out of 3: i. oleum, ii. 2 oleum equations (**OR** descriptions), iii. significance
1 Mark	Oleum **OR** Significance **OR** 1 equation/description

(c)(i) $2\ NaCl(aq) + CaCO_3(s) \rightarrow Na_2CO_3(s) + CaCl_2(aq)$

(c)(ii) Filtration.

(d)

Criteria	Marks
• Demonstrates a thorough understanding of the chemistry and production methods of sodium hydroxide (Hg cell) AND soaps AND • Discusses environmental issues associated with both processes	6-7
• Demonstrates a good understanding of the chemistry and production methods of sodium hydroxide (Hg process) OR soaps AND • Discusses environmental issues arising from either process	4-5
• Discusses environmental issues arising from either process OR • Demonstrates some understanding of the chemistry and production methods of sodium hydroxide (Hg process) OR soaps AND • Discusses an environmental issue arising from either process OR • Outlines environmental issues arising from either process	2-3
• One aspect of the production of NaOH or soap is identified OR • Environmental issue identified	1

No discussion of saponification chemistry = 5 max
Discussion of environmental issues restricted to Hg only = 3 max
Little discussion of the relevant chemistry = 3 max

A thorough understanding of the chemistry and production methods involved writing balanced chemical equations for (at least) the overall process, plus descriptions of steps with related environmental issues. Commonly discussed environmental issues included the following:

Hg cell
- Mercury toxicity, bioaccumulation
- Thermal pollution related to waste brine
- Large energy input → fossil fuel emissions

Soap manufacture
- No large environmental issues
- Energy input to heat the reaction vessel → fossil fuel emissions
- Some associated thermal pollution
- (Positive) environmental impact of using waste fats/oils