



**2016**  
**FORM VI**  
**TRIAL HSC EXAMINATION**

# Chemistry

Monday 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 and master's initials 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	

Chemistry Classes:

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

**Section I** Pages 3 - 20

**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 21-33
- Allow about 1 hour and 45 minutes for this Section

**Section II** Pages 21-25

Total marks (25)

- Attempt Question 34 in this section.
- Allow about 45 minutes for this Section

**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)      (B)      (C)      (D)

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

(A)      (B)      (C)      (D)

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.

(A)      (B)      (C)      (D)

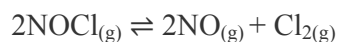
*correct*

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- 1 Which of the following is the correct combination of acid/base indicator, colour change and pH range?

	Indicator	pH range of colour change	Colour Change
(A)	phenolphthalein	8.3 - 10	purple - colourless
(B)	methyl orange	3.1 - 4.4	red - yellow
(C)	bromothymol blue	8.7 - 10.3	yellow - blue
(D)	bromothymol blue	8.7 - 10.3	blue - yellow

- 2 Consider the gaseous system shown below, enclosed in a container of constant volume.

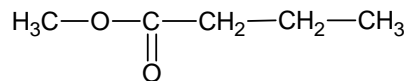


Which of the following will NOT affect the position of equilibrium?

- (A) Adding NO  
(B) Removing  $\text{Cl}_2$   
(C) Adding argon  
(D) Heating the system
- 3 What general trend can be observed about the oxides of period 3 elements?
- (A) As you move from left to right across the period the oxides go from being basic, to amphoteric, to acidic.  
(B) As you move from left to right across the period the oxides go from being highly reactive to inert.  
(C) As you move from left to right across the period the oxides go from being gases, to liquids, to solids.  
(D) As you move from left to right across the period the oxides go from being molecular to lattice structures.
- 4 What is the correct systematic name for citric acid?
- (A) vitamin C  
(B) 2-hydroxy-glycerol  
(C) 2-carboxy-1,2,3-trihydroxypropane  
(D) 2-hydroxypropane-1,2,3-tricarboxylic acid

- 5 Which of the following is Davy's definition of an acid?
- (A) A substance which contains hydrogen.
  - (B) A substance which contains oxygen.
  - (C) A substance which dissolves in water to produce  $H^+$ .
  - (D) A substance which is able to donate a proton.

- 6 What is the correct name for the following compound?



- (A) methyl propanoate
  - (B) butyl methanoate
  - (C) propyl methanoate
  - (D) methyl butanoate
- 7 Which of the following represents an acid/base conjugate pair?
- (A)  $NH_3 / NH_2^-$
  - (B)  $H_2O / H_2O_2$
  - (C)  $CH_3COOH / CH_3CH_2OH$
  - (D)  $CH_3CHOHCH_3 / CH_3COCH_3$
- 8 What are alkyl alkanoates more commonly known as?
- (A) glycerols
  - (B) glycols
  - (C) ethers
  - (D) esters
- 9 If it takes 15 mL of a 0.5 M solution of HCl to completely neutralise a given amount of calcium hydroxide, what volume of 0.5 M ethanoic acid would be required to neutralise the same amount of calcium hydroxide?
- (A) less than 15 mL
  - (B) exactly 15 mL
  - (C) more than 15 mL
  - (D) 1.154 L

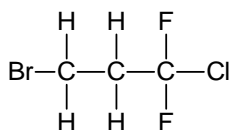
- 10 Which of the following could result from cracking a single octane molecule?
- (A) two butane molecules
  - (B) one butane molecule and one butene molecule
  - (C) two butene molecules
  - (D) three propene molecules
- 11 When bromine water is added to hexane and the mixture shaken, why does the hexane layer turn brown?
- (A) The water quickly reacts with the hexane to form a substitution compound.
  - (B) The bromine slowly reacts with the hexane to form a substitution compound.
  - (C) The bromine quickly reacts with the hexane to form a substitution compound.
  - (D) The bromine dissolves in the hexane.
- 12 Which of the following conditions promotes the fermentation of sugars?
- (A) A highly acidic environment.
  - (B) A temperature of 78 °C.
  - (C) An anaerobic environment.
  - (D) The addition of the enzyme catalase.
- 13 Which of the following lists contains metals which will **all** displace tin from a solution of tin(II) chloride?
- (A) silver, iron, zinc
  - (B) iron, zinc, magnesium
  - (C) copper, silver, zinc
  - (D) zinc, magnesium, copper
- 14 Which of the following is the purpose of a salt bridge in a galvanic cell?
- (A) To maintain the electrical neutrality of each half cell.
  - (B) To provide a path for electron flow between the half cells.
  - (C) To replenish the reactants as they are consumed.
  - (D) To remove spectator ions from each half cell.

- 15 The standard cell potential of an electrochemical reaction is positive. What does this mean?
- (A) The reaction is not spontaneous under any conditions.  
(B) The reaction is only spontaneous under standard conditions.  
(C) The reaction is always spontaneous under all conditions.  
(D) The reaction is spontaneous under standard conditions.

- 16 A 0.132 g sample of anhydrous sodium carbonate is dissolved in water, transferred to a 250 mL volumetric flask and the resulting solution made up to the mark with deionised water. What is the concentration of sodium ions in this solution?

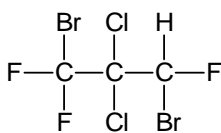
- (A) 0.00125 mol L<sup>-1</sup>  
(B) 0.00250 mol L<sup>-1</sup>  
(C) 0.00500 mol L<sup>-1</sup>  
(D) 0.0100 mol L<sup>-1</sup>

- 17 What is the name of the haloalkane whose structure is shown below?



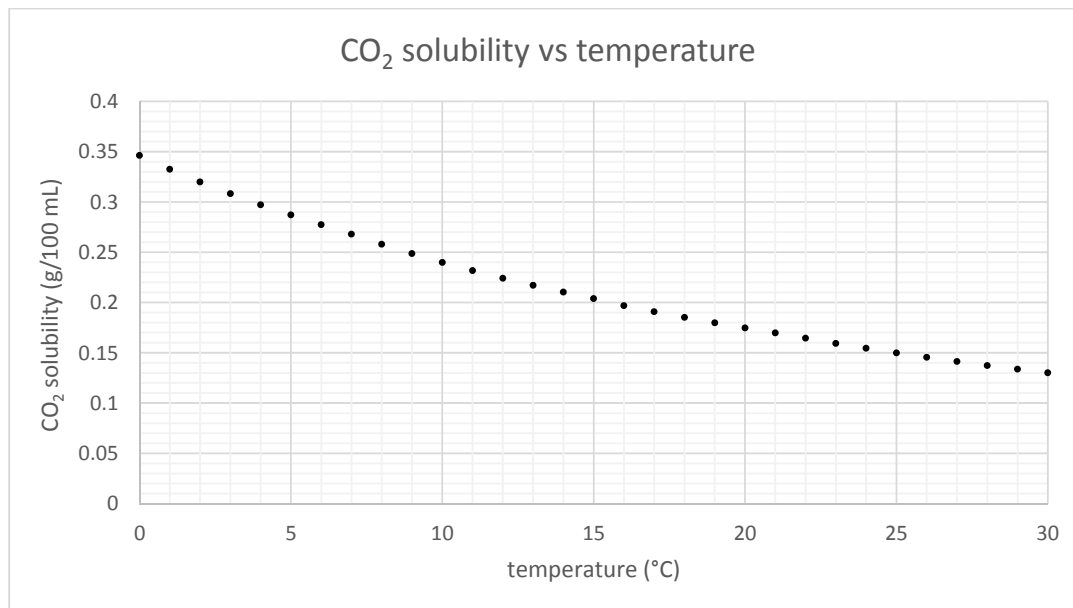
- (A) 3-bromo-1-chloro-1,1-difluoropropane  
(B) 1-bromo-3-chloro-3-difluoropropane  
(C) 3-bromo-1-chloro-1-difluoropropane  
(D) 1-bromo-3-chloro-3,3-difluoropropane
- 18 1.35 g of a fertiliser containing 56.7% ammonium sulfate by mass was dissolved in water. 10.00 g of solid barium chloride is added and the barium sulfate produced is filtered, washed and dried. What is the mass of dry barium sulfate expected from the fertiliser?
- (A) 0.555 g  
(B) 0.764 g  
(C) 1.35 g  
(D) 3.28 g

- 19 Which of the following is an isomer of the haloalkane whose structure is shown below?



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

- 20 The following graph shows the solubility of carbon dioxide in water as a function of temperature.



What volume of CO<sub>2</sub> gas is released when a 600 mL of water saturated with carbon dioxide at 5.0 °C is warmed to 25.0 °C?

- (A) 0.135 L  
 (B) 0.456 L  
 (C) 0.810 L  
 (D) 1.44 L

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**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** (4 marks)**Marks**

Explain the formation and effects of acid rain, using equations where appropriate.

**4**

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**Question 22** (5 marks)**Marks**

The addition of an active metal to an acid produces a salt plus hydrogen gas.

- (a) Write an equation for the reaction of magnesium with hydrochloric acid.

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**1**

- (b) Calculate the volume of 0.550 M hydrochloric acid that would be required to completely react with 30.0 g of magnesium.

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**3**

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- (c) Calculate the volume of hydrogen gas that would be produced, from the reaction described in part (b) of this question, if the reaction took place at 0 °C and 100 kPa.

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**1**

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**Question 23** (5 marks)**Marks**

In a chemical experiment 26.2 mL of 0.680 M sulfuric acid solution is mixed with 37.5 mL of 1.38 M sodium hydroxide solution.

- (a) Write a balanced chemical equation for this reaction.

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**1**

- (b) Assuming that there is no volume change, calculate the pH of the resulting solution.

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**4**

**Question 24** (6 marks)**Marks**

Esterification can be performed in a school laboratory.

- (a) Explain the purpose of adding concentrated sulfuric acid to this reaction.

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**1**

- (b) Using structural formulae, write a chemical equation for the experiment you performed.

**2**

- (c) With the aid of a diagram, or otherwise, describe the equipment used in this experiment and justify its use.

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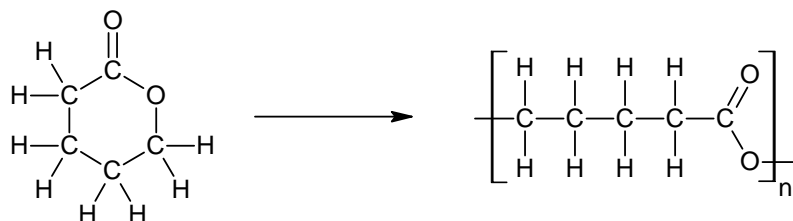
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**3**

**Question 25** (2 marks)**Marks**

Polybutyrolactone is a renewable biodegradable polyester. It can be made from butyrolactone according to the following equation.



- (a) Draw an expanded structural formula of the polymer showing 2 repeat units.

**1**

- (b) Draw the monomer that would be required to make polybutyrolactone by condensation polymerisation.

**1**

**Question 26** (3 marks)**Marks**

Draw and name all products that result from the reaction of hydrogen chloride with 3-bromopropene.

**3**

**Question 27** (4 marks)**Marks**

“The dehydration of ethanol to ethene is the key reaction in a sequence of reactions that enables the sustainable production of polyethene from biomass.”

Draw a flow diagram to show how biomass (cellulose) can be converted to polyethylene. The flow diagram should name and outline the processes undertaken as well as the products formed.

**4**

**Question 28** (6 marks)**Marks**

- (a) Determine the minimum mass of ethanol that must be combusted in order to heat 500.0 g water from 20.0 °C to 100.0 °C given that the enthalpy of combustion for ethanol is  $-1367 \text{ kJmol}^{-1}$ .

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- (b) Write an equation for the complete combustion of ethanol.

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- (c) Explain the need to monitor combustion reactions such as the combustion of petrol in cars.

**2**

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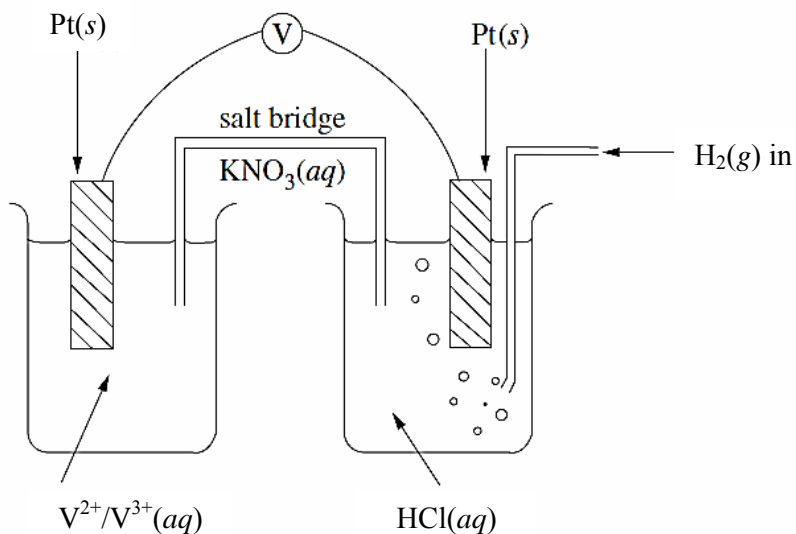
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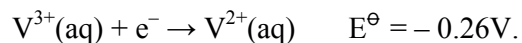


**Question 29** (4 marks)**Marks**

The diagram below displays a  $\text{Pt}|\text{V}^{2+}, \text{V}^{3+}||\text{H}^+|\text{H}_2|\text{Pt}$  galvanic cell.



The Standard Reduction Potential for the species in the half-cell on the left is shown below:



- (a) On the diagram, clearly label the anode and the direction of electron flow.

**2**

- (b) Write the net ionic equation for the reaction

**1**


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- (c) Calculate the standard cell potential for this galvanic cell.

**1**


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**Question 30** (2 marks)**Marks**

High quality phosphorous-doped silicon is made at the Australian Lucas Heights nuclear reactor by immersing essentially perfectly formed silicon crystals into a “neutron bath”.

Write the two successive reactions that are responsible for the conversion of silicon-28 into phosphorus-29.

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**2**

**Question 31** (4 marks)**Marks**

A student dissolves an unknown solid in water. When the resulting solution is mixed with the following solutions, the student records these observations:

Solution	Observations
barium chloride	white precipitate forms
sodium hydroxide	brown precipitate forms
lead(II) nitrate	no visible reaction

The student concludes that the unknown solid is iron(III) sulfate.

Assess the validity of the student's conclusion.

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**4**

**Question 32** (6 marks)**Marks**

Farmer Heinz has harvested a very successful crop of beans, whereas neighbouring Farmer Stagg's crop is less impressive. Farmer Heinz says that the availability of some trace elements in soil varies with pH and suggests that their soil manganese levels might differ as a result of different soil pH.

Explain how you could use atomic absorption spectroscopy and any other relevant techniques to assess the validity of this hypothesis.

**6**

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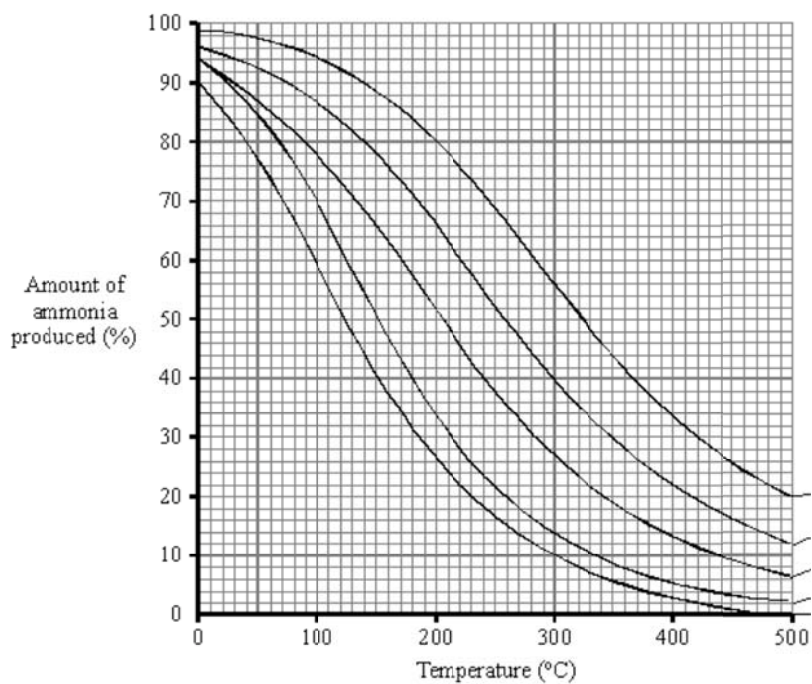
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**Question 33** (4 marks)**Marks**

The following is a graph of percentage conversion of nitrogen and hydrogen to ammonia against temperature, for pressures between 25 and 400 atm.



- (a) On the graph, clearly label the line corresponding to a pressure of 400 atm.

**1**

- (b) With reference to the graph, explain the choice of temperature for the commercial production of ammonia.

**3**

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**Section II****25 marks****Attempt question 34 in this section.****Allow about 45 minutes for this section.**

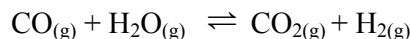
Answer the question in a **writing booklet**. Extra writing booklets are available.  
Show **all** relevant working in questions involving calculations.

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	<b>Pages</b>
<b>Question 34</b>	<b>Industrial Chemistry.....23-25</b>
<b>Question 35</b>	<b>Elective 2</b>
<b>Question 36</b>	<b>Elective 3</b>
<b>Question 37</b>	<b>Elective 4</b>
<b>Question 38</b>	<b>Elective 5</b>

**Question 34** (25 marks)**Marks**

- (a) The Water-gas shift reaction (WGSR) is an important industrial reaction and can be written as per below.



At 588 K, the equilibrium constant is 31.4.

- |       |  |          |
|-------|--|----------|
| (i)   | Write the expression for the equilibrium constant.   | <b>1</b> |
| (ii)  | The equilibrium constant decreases with an increase in temperature for this reaction. Is the forward reaction exothermic or endothermic? Justify your answer.  | <b>2</b> |
| (iii) | 2.50 moles each of both $\text{CO}_{(g)}$ and $\text{H}_2\text{O}_{(g)}$ and 5.00 moles each of $\text{CO}_{2(g)}$ and $\text{H}_{2(g)}$ are added at 588 K to a 10 L vessel. Calculate the concentration of $\text{H}_{2(g)}$ at equilibrium. | <b>3</b> |
| (b)   | Molten sulfur is often transported to sulfuric acid plants by truck. Describe the chemistry and justify the conditions used during the industrial production of sulfuric acid from molten sulfur.  | <b>7</b> |
| (c)   | Compare the structure of a soap with that of one specific type of detergent.   | <b>2</b> |

**Question 34 continued on next page.**



# Complete parts (d) and (e) in a new Answer Booklet.

- |     |   |   |
|-----|---|---|
| (d) | Account for the cleaning action of soap.  | 3 |
| (e) | (i) Identify the feedstock that is common to both the Solvay process and the production of NaOH.  | 1 |
|     | (ii) Compare the factors affecting the location of a chemical plant to produce NaOH using a mercury cell with the factors affecting the location of a chemical plant to perform the Solvay process. | 3 |
|     | (iii) Calculate the mass of the desired product of the Solvay process if 1.00 tonnes of calcium carbonate is completely used up.  | 3 |

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## Chemistry

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**Data Sheet**

Avogadro's constant, $N_A$ .....	$6.022 \times 10^{23} \text{ mol}^{-1}$
Volume of 1 mole ideal gas: at 100 kPa and	
at 0 °C (273 K) .....	22.71L
at 25 °C (298K) .....	24.79 L
Ionisation constant for water at 25°C (298.15 K), $K_w$ .....	$1.0 \times 10^{-14}$
Specific heat capacity of water .....	$4.18 \times 10^3 \text{ Jkg}^{-1}\text{K}^{-1}$

**Some useful formulae**

$$\text{pH} = -\log_{10}[\text{H}^+]$$

$$q = mC\Delta T$$

**Standard Potentials**

$\text{K}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{K}_{(\text{s})}$	-2.94 V
$\text{Ba}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ba}_{(\text{s})}$	-2.91 V
$\text{Ca}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ca}_{(\text{s})}$	-2.87 V
$\text{Na}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Na}_{(\text{s})}$	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Mg}_{(\text{s})}$	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	$\rightleftharpoons$	$\text{Al}_{(\text{s})}$	-1.68 V
$\text{Mn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Mn}_{(\text{s})}$	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2} \text{H}_{2(\text{g})} + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Zn}_{(\text{s})}$	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Fe}_{(\text{s})}$	-0.44 V
$\text{Ni}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ni}_{(\text{s})}$	-0.24 V
$\text{Sn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Sn}_{(\text{s})}$	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Pb}_{(\text{s})}$	-0.13 V
$\text{H}^+ + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2} \text{H}_{2(\text{g})}$	0.00 V
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{SO}_{2(\text{g})} + 2\text{H}_2\text{O}$	0.16 V
$\text{Cu}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Cu}_{(\text{s})}$	0.34 V
$\frac{1}{2} \text{O}_{2(\text{g})} + \text{H}_2\text{O} + 2\text{e}^-$	$\rightleftharpoons$	$2\text{OH}^-$	0.40 V
$\text{Cu}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Cu}_{(\text{s})}$	0.52 V
$\frac{1}{2} \text{I}_{2(\text{s})} + \text{e}^-$	$\rightleftharpoons$	$\text{I}^-$	0.54 V
$\frac{1}{2} \text{I}_{2(\text{aq})} + \text{e}^-$	$\rightleftharpoons$	$\text{I}^-$	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	$\rightleftharpoons$	$\text{Fe}^{2+}$	0.77 V
$\text{Ag}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Ag}_{(\text{s})}$	0.80 V
$\frac{1}{2} \text{Br}_{2(\text{l})} + \text{e}^-$	$\rightleftharpoons$	$\text{Br}^-$	1.08 V
$\frac{1}{2} \text{Br}_{2(\text{aq})} + \text{e}^-$	$\rightleftharpoons$	$\text{Br}^-$	1.10 V
$\frac{1}{2} \text{O}_2 + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{H}_2\text{O}$	1.23 V
$\frac{1}{2} \text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	$\rightleftharpoons$	$\text{Cr}^{3+} + \frac{7}{2} \text{H}_2\text{O}$	1.36 V
$\frac{1}{2} \text{Cl}_{2(\text{g})} + \text{e}^-$	$\rightleftharpoons$	$\text{Cl}^-$	1.36 V
$\frac{1}{2} \text{Cl}_{2(\text{aq})} + \text{e}^-$	$\rightleftharpoons$	$\text{Cl}^-$	1.40 V
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	$\rightleftharpoons$	$\text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51 V
$\frac{1}{2} \text{F}_{2(\text{g})} + \text{e}^-$	$\rightleftharpoons$	$\text{F}^-$	2.89 V

## PERIODIC TABLE OF THE ELEMENTS

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1	H	1.008	Hydrogen	1	H	1.008	Hydrogen	2	He	4.003	Helium	3	Li	6.941	Lithium	4	Be	9.012	Beryllium	5	B	10.81	Boron	6	C	12.01	Carbon	7	N	14.01	Nitrogen	8	O	16.00	Oxygen	9	F	19.00	Fluorine	10	Ne	20.18	Neon	11	Na	22.99	Sodium	12	Mg	24.31	Magnesium	13	Al	26.98	Aluminium	14	Si	28.09	Silicon	15	P	30.97	Phosphorus	16	S	32.07	Sulfur	17	Cl	35.45	Chlorine	18	Ar	39.95	Argon	19	K	39.10	Potassium	20	Ca	40.08	Calcium	21	Sc	44.96	Scandium	22	Ti	47.87	Titanium	23	V	50.94	Vanadium	24	Cr	52.00	Chromium	25	Mn	54.94	Manganese	26	Fe	55.85	Iron	27	Co	58.93	Cobalt	28	Ni	58.69	Nickel	29	Cu	63.55	Copper	30	Zn	65.38	Zinc	31	Ga	69.72	Gallium	32	Ge	72.64	Germanium	33	As	74.92	Arsenic	34	Se	78.96	Selenium	35	Br	79.90	Bromine	36	Kr	83.80	Krypton	37	Rb	85.47	Rubidium	38	Sr	87.62	Strontium	39	Y	88.91	Yttrium	40	Zr	91.22	Zirconium	41	Nb	92.91	Niobium	42	Mo	95.96	Molybdenum	43	Tc		Technetium	44	Ru	101.1	Ruthenium	45	Rh	102.9	Rhodium	46	Pd	106.4	Palladium	47	Ag	107.9	Silver	48	Cd	112.4	Cadmium	49	In	114.8	Indium	50	Sn	118.7	Tin	51	Sb	121.8	Antimony	52	Te	127.6	Tellurium	53	I	126.9	Iodine	54	Xe	131.3	Xenon	55	Cs	132.9	Cesium	56	Ba	137.3	Barium	57-71	Lanthanoids	72	Hf	178.5	Hafnium	73	Ta	180.9	Tantalum	74	W	183.9	Tungsten	75	Re	186.2	Rhenium	76	Os	190.2	Osmium	77	Ir	192.2	Iridium	78	Pt	195.1	Platinum	79	Au	197.0	Gold	80	Hg	200.6	Mercury	81	Tl	204.4	Thallium	82	Pb	207.2	Lead	83	Bi	209.0	Bismuth	84	Po		Polonium	85	At		Astatine	86	Rn		Radon	87	Fr		Francium	88	Ra		Radium	89-103	Actinoids	104	Rf		Rutherfordium	105	Db		Dubnium	106	Sg		Seaborgium	107	Bh		Bohrium	108	Hs		Hassium	109	Mt		Meitnerium	110	Ds		Darmstadtium	111	Rg		Roentgenium	112	Cn		Copernicium	113	Uut		Ununtrium	114	F1		Flerovium	115	Uup		Ununpentium	116	Lv		Livermorium	117	Uus		Ununseptium	118	Uuo		Ununoctium	109	La	138.9	Lanthanum	110	Ce	140.1	Cerium	111	Pr	140.9	Praseodymium	112	Nd	144.2	Neodymium	113	Pm		Promethium	114	Sm	150.4	Samarium	115	Eu	152.0	Europium	116	Gd	157.3	Gadolinium	117	Tb	158.9	Terbium	118	Dy	162.5	Dysprosium	119	Ho	164.9	Holmium	120	Er	167.3	Erbium	121	Tm	168.9	Thulium	122	Yb	173.1	Ytterbium	123	Lu	175.0	Lutetium	124	Ac	227.0	Actinium	125	Th	232.0	Thorium	126	Pa	231.0	Protactinium	127	U	238.0	Uranium	128	Np		Neptunium	129	Pu		Plutonium	130	Am		Americium	131	Cm		Curium	132	Bk		Berkelium	133	Cf		Californium	134	Es		Einsteinium	135	Fm		Fermium	136	Md		Mendelevium	137	No		Nobelium	138	Lr		Lawrencium

Standard atomic weights are abridged to four significant figures.

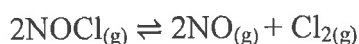
Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (January 2016 version). The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

- 1 Which of the following is the correct combination of acid/base indicator, colour change and pH range?

	Indicator	pH range of colour change	Colour Change
(A)	phenolphthalein	8.3 - 10	purple - colourless
(B)	methyl orange	3.1 - 4.4	red - yellow
(C)	bromothymol blue	8.7 - 10.3	yellow - blue
(D)	bromothymol blue	8.7 - 10.3	blue - yellow

- 2 Consider the gaseous system shown below, enclosed in a container of constant volume.



Which of the following will NOT affect the position of equilibrium?

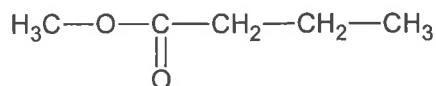
- (A) Adding NO  
(B) Removing Cl<sub>2</sub>  
(C) Adding argon  
(D) Heating the system
- 3 What general trend can be observed about the oxides of period 3 elements?
- (A) As you move from left to right across the period the oxides go from being basic, to amphoteric, to acidic.  
(B) As you move from left to right across the period the oxides go from being highly reactive to inert.  
(C) As you move from left to right across the period the oxides go from being gases, to liquids, to solids.  
(D) As you move from left to right across the period the oxides go from being molecular to lattice structures.
- 4 What is the correct systematic name for citric acid?

- (A) vitamin C  
(B) 2-hydroxy-glycerol  
(C) 2-carboxy-1,2,3-trihydroxypropane  
(D) 2-hydroxypropane-1,2,3-tricarboxylic acid

5 Which of the following is Davy's definition of an acid?

- (A) A substance which contains hydrogen.
- (B) A substance which contains oxygen.
- (C) A substance which dissolves in water to produce  $H^+$ .
- (D) A substance which is able to donate a proton.

6 What is the correct name for the following compound?



- (A) methyl propanoate
- (B) butyl methanoate
- (C) propyl methanoate
- (D) methyl butanoate

7 Which of the following represents an acid/base conjugate pair?

- (A)  $NH_3 / NH_2^-$
- (B)  $H_2O / H_2O_2$
- (C)  $CH_3COOH / CH_3CH_2OH$
- (D)  $CH_3CHOHCH_3 / CH_3COCH_3$

8 What are alkyl alkanoates more commonly known as?

- (A) glycerols
- (B) glycols
- (C) ethers
- (D) esters

9 If it takes 15 mL of a 0.5 M solution of HCl to completely neutralise a given amount of calcium hydroxide, what volume of 0.5 M ethanoic acid would be required to neutralise the same amount of calcium hydroxide?

- (A) less than 15 mL
- (B) exactly 15 mL
- (C) more than 15 mL
- (D) 1.154 L

- 10 Which of the following could result from cracking a single octane molecule?
- (A) two butane molecules
  - (B) one butane molecule and one butene molecule**
  - (C) two butene molecules
  - (D) three propene molecules
- 11 When bromine water is added to hexane and the mixture shaken, why does the hexane layer turn brown?
- (A) The water quickly reacts with the hexane to form a substitution compound.
  - (B) The bromine slowly reacts with the hexane to form a substitution compound.
  - (C) The bromine quickly reacts with the hexane to form a substitution compound.
  - (D) The bromine dissolves in the hexane.**
- 12 Which of the following conditions promotes the fermentation of sugars?
- (A) A highly acidic environment.
  - (B) A temperature of 78 °C.
  - (C) An anaerobic environment.**
  - (D) The addition of the enzyme catalase.
- 13 Which of the following lists contains metals which will **all** displace tin from a solution of tin(II) chloride?
- (A) silver, iron, zinc
  - (B) iron, zinc, magnesium**
  - (C) copper, silver, zinc
  - (D) zinc, magnesium, copper
- 14 Which of the following is the purpose of a salt bridge in a galvanic cell?
- (A) To maintain the electrical neutrality of each half cell.**
  - (B) To provide a path for electron flow between the half cells.
  - (C) To replenish the reactants as they are consumed.
  - (D) To remove spectator ions from each half cell.

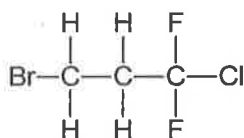
15 The standard cell potential of an electrochemical reaction is positive. What does this mean?

- (A) The reaction is not spontaneous under any conditions.
- (B) The reaction is only spontaneous under standard conditions.
- (C) The reaction is always spontaneous under all conditions.
- (D) **The reaction is spontaneous under standard conditions.**

16 A 0.132 g sample of anhydrous sodium carbonate is dissolved in water, transferred to a 250 mL volumetric flask and the resulting solution made up to the mark with deionised water. What is the concentration of sodium ions in this solution?

- (A) 0.00125 mol L<sup>-1</sup>
- (B) 0.00250 mol L<sup>-1</sup>
- (C) 0.00500 mol L<sup>-1</sup>
- (D) **0.0100 mol L<sup>-1</sup>**

17 What is the name of the haloalkane whose structure is shown below?



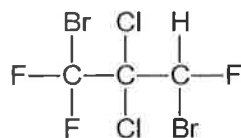
- (A) **3-bromo-1-chloro-1,1-difluoropropane**
- (B) 1-bromo-3-chloro-3-difluoropropane
- (C) 3-bromo-1-chloro-1-difluoropropane
- (D) 1-bromo-3-chloro-3,3-difluoropropane

18 1.35 g of a fertiliser containing 56.7% ammonium sulfate by mass was dissolved in water. 10.00 g of solid barium chloride is added and the barium sulfate produced is filtered, washed and dried. What is the mass of dry barium sulfate expected from the fertiliser?

- (A) 0.555 g
- (B) 0.764 g
- (C) **1.35 g**
- (D) 3.28 g

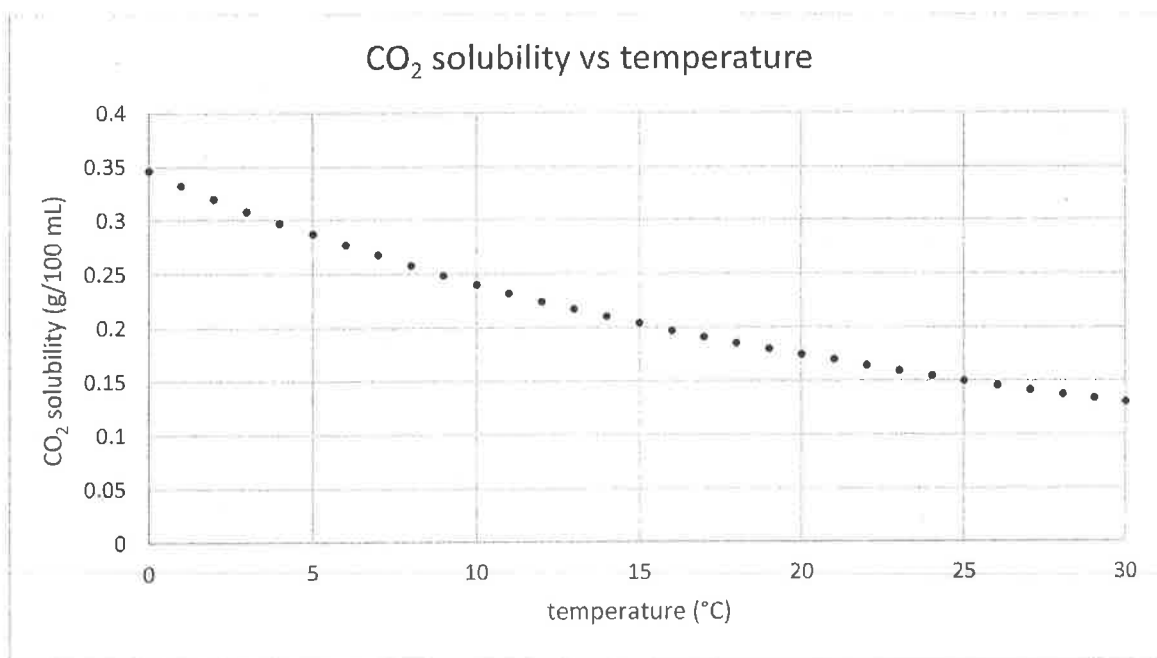


- 19 Which of the following is an isomer of the haloalkane whose structure is shown below?



(A) $\begin{array}{ccccc} & \text{Br} & \text{Cl} & \text{Br} & \\ &   &   &   & \\ \text{F} & -\text{C} & -\text{C} & -\text{C} & -\text{F} \\ &   &   &   & \\ & \text{H} & \text{Cl} & \text{Br} & \end{array}$	(B) $\begin{array}{ccccc} & \text{F} & \text{F} & \text{F} & \\ &   &   &   & \\ \text{Cl} & -\text{C} & -\text{C} & -\text{C} & -\text{F} \\ &   &   &   & \\ & \text{Br} & \text{Cl} & \text{Br} & \end{array}$
(C) $\begin{array}{ccccc} & \text{Br} & \text{Cl} & \text{F} & \\ &   &   &   & \\ \text{F} & -\text{C} & -\text{C} & -\text{C} & -\text{Br} \\ &   &   &   & \\ & \text{Cl} & \text{F} & \text{H} & \end{array}$	(D) $\begin{array}{ccccc} & \text{F} & \text{H} & \text{H} & \\ &   &   &   & \\ \text{F} & -\text{C} & -\text{C} & -\text{C} & -\text{F} \\ &   &   &   & \\ & \text{Cl} & \text{Cl} & \text{Br} & \end{array}$

- 20 The following graph shows the solubility of carbon dioxide in water as a function of temperature.



What volume of CO<sub>2</sub> gas is released when a 600 mL of water saturated with carbon dioxide at 5.0 °C is warmed to 25.0 °C?

- (A) 0.135 L  
 (B) 0.456 L  
 (C) 0.810 L  
 (D) 1.44 L

## 2016 Trial Mark Scheme Ques 21 – 24 (AKBB)

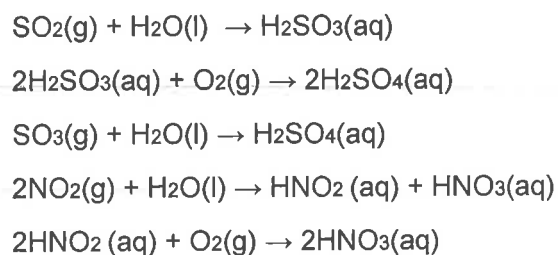
### Ques 21

4 Marks	Comprehensive discussion of the formation & effects of acid rain, including at least <b>one</b> relevant equation for the formation and <b>one</b> for the effects.
3 Marks	Comprehensive discussion of <b>EITHER</b> the formation <b>OR</b> effects of acid rain, <b>AND</b> a brief discussion of the other, as well as at least <b>one</b> relevant equation.  <b>OR</b>  Brief discussion of the formation <b>AND</b> effects of acid rain, including at least <b>two</b> relevant equations.  <b>OR</b>  Comprehensive discussion of <b>EITHER</b> the formation <b>OR</b> effects of acid rain, including at least <b>two</b> relevant equations.
2 marks	Brief discussion of the formation <b>AND</b> effects of acid rain.  <b>OR</b>  Comprehensive discussion of the formation <b>OR</b> effects of acid rain.
1 mark	Brief discussion of the formation <b>OR</b> effects of acid rain.  <b>OR</b>  Equation of the formation <b>OR</b> effects of acid rain.

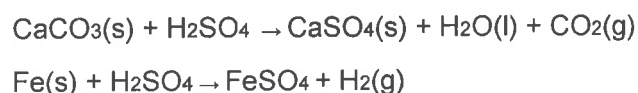
#### Problems

FDM - Formation Discussion Missing  
EFM – Effects Discussion Missing  
FDW - Formation Discussion Weak  
EDW - Effects Discussion Weak  
FEM -Formation Equation Missing  
EEM - Effects Equation Missing

#### Formation equations



#### Effects equations



Ques 22



b 30.0g of Mg is  $30/24.31 = 1.234$  mol 1 mark

2 x 1.234 mol of HCl 1 mark

$$\text{Vol} = 2 \times 1.234 / 0.550$$

$$= 4.49\text{L} \quad \text{1 mark}$$

c Vol of  $\text{H}_2 = 1.234 \times 22.71$

$$= 28.0\text{L} \quad \text{1 mark}$$

Ques 23



*(equation of first protonation of the acid or equation shown as an equilibrium not accepted)*

b

	$\text{H}_2\text{SO}_4$	$\text{NaOH}$	Marks
n	$0.0262 \times 0.68$	$0.0375 \times 1.38$	
	$= 0.0178$ mol	$= 0.05175$ mol	1
ratio	1 (0.0178) : 2 (0.0356)		
	limiting	excess = 0.0161mol	1
conc		$0.0161 / (0.0262 + 0.0375)$ $= 0.253\text{M}$	1
pOH		$-\log_{10}[0.253]$ $= 0.597$	
pH		$14 - 0.597$ $= 13.4$	1

Ques 24

a catalyst 1 mark

b \*correct organic components 1 mark

\*double headed arrow, conc  $\text{H}_2\text{SO}_4$  and water 1 mark

c \*heated reaction vessel and condenser identified 1 mark

*(simply identifying the apparatus as reflux is NOT a description)*

*(many boys seemed to confuse the terms condenser and refluxer)*

\*reactants heated in order to increase reaction rate 1 mark

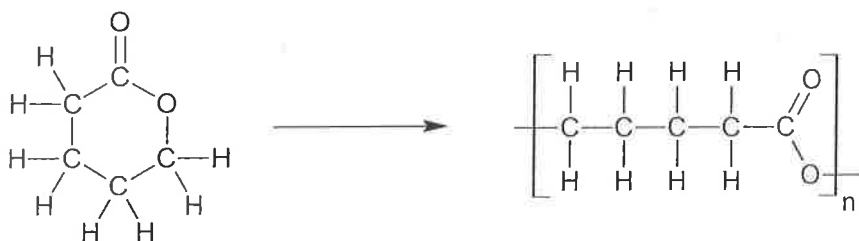
\*gaseous mixture of reactants and products condensed to prevent them escaping to the atmosphere 1 mark

**Somewhat holistically marked. For 3 marks the answer had to be comprehensive and perfect.**

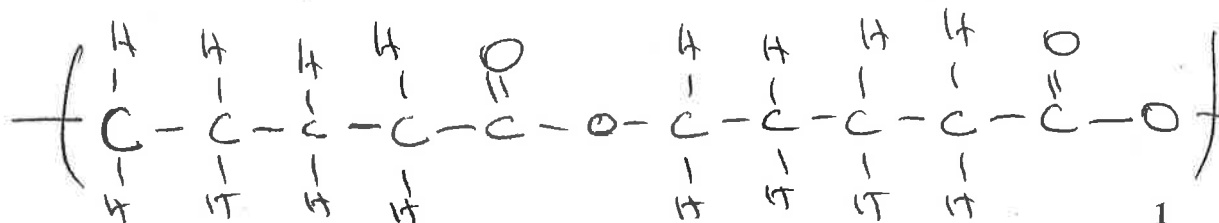
**Question 25** (2 marks)

**Marks**

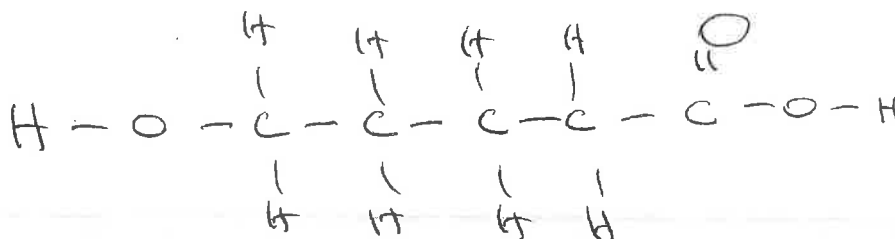
Polybutyrolactone is a renewable biodegradable polyester. It can be made from butyrolactone according to the following equation.



- (a) Draw an expanded structural formula of the polymer showing 2 repeat units.



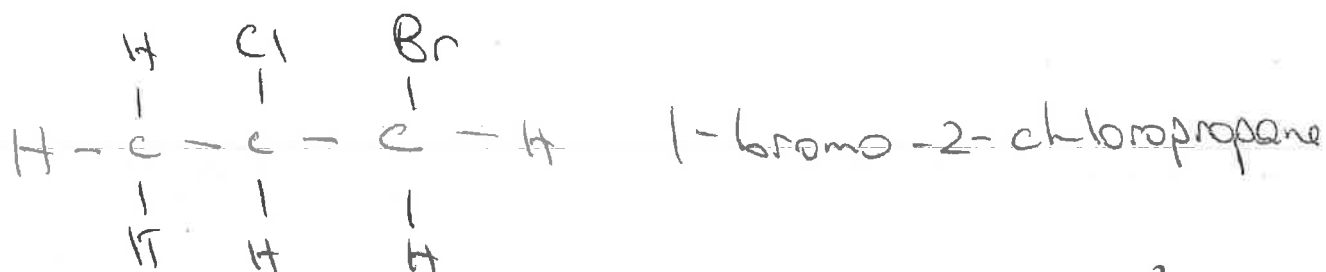
- (b) Draw the monomer that would be required to make polybutyrolactone by condensation polymerisation.



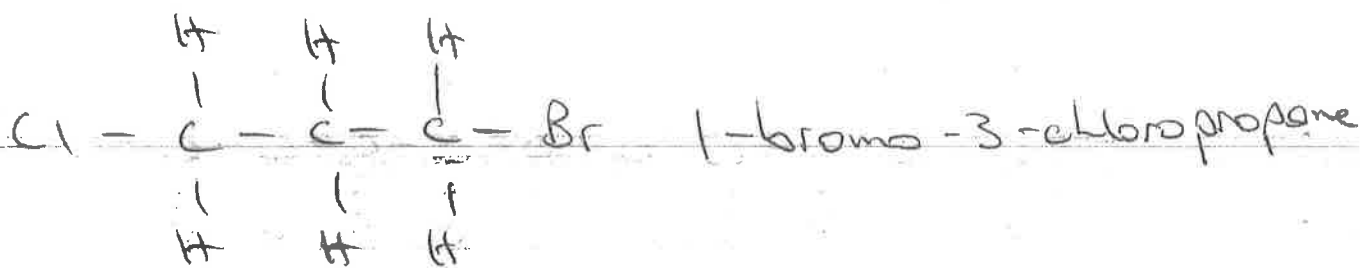
## Question 26 (3 marks)

Marks

Draw and name all products that result from the reaction of hydrogen chloride with 3-bromopropene.



3



1 mark for each correct structure (2)

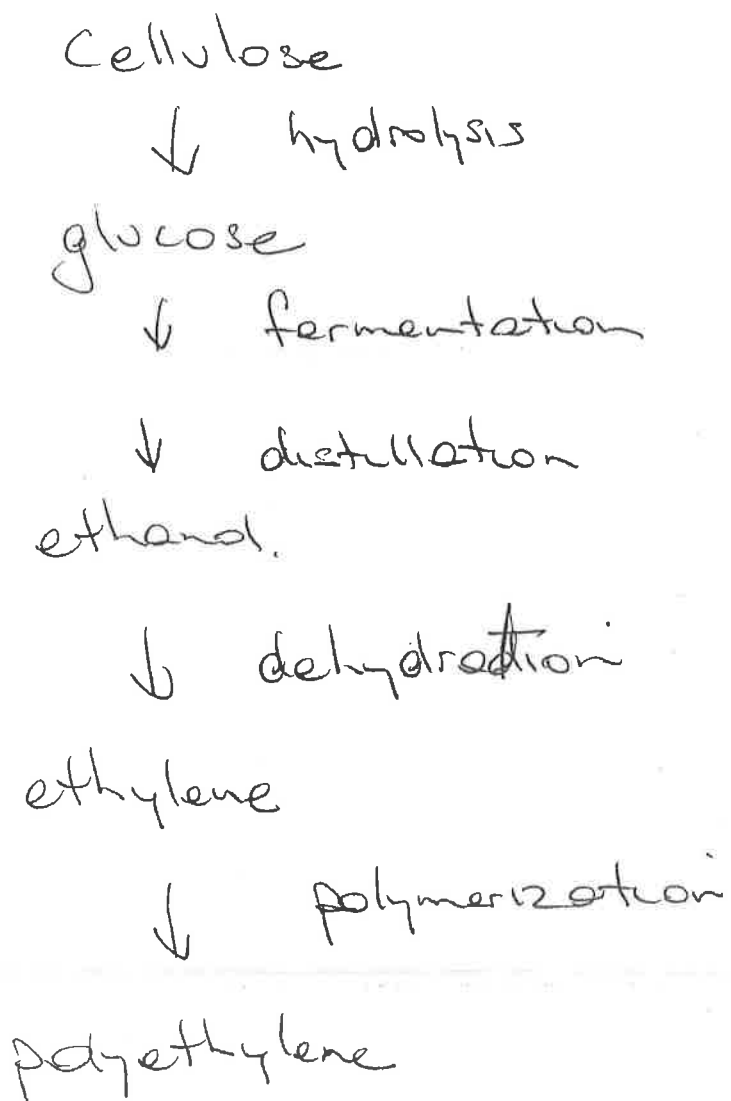
1 mark for both names correct

Question 27 (4 marks)

Marks

“The dehydration of ethanol to ethene is the key reaction in a sequence of reactions that enables the sustainable production of polyethene from biomass.”

Draw a flow diagram to show how biomass (cellulose) can be converted to polyethene. The flow diagram should name and outline the processes undertaken as well as the products formed.



- 1 mark all products
- 2 marks all process names (mark one missing)
- 1 mark for 2 or more process outlines.

## Question 28 (6 marks)

Marks

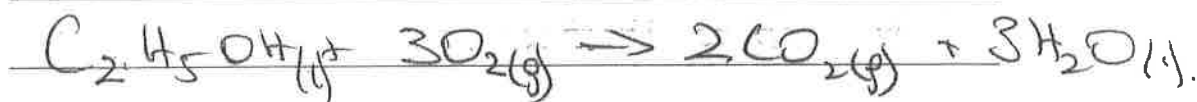
- (a) Determine the minimum mass of ethanol that must be combusted in order to heat 500.0 g water from 20.0 °C to 100.0 °C given that the enthalpy of combustion for ethanol is  $-1367 \text{ kJmol}^{-1}$ .

1 mark  $q = m C \Delta T = 0.5000 \times 4.18 \times 80.0$  3  
 $= 167.2 \text{ kJ}$

1 mark  $n_{\text{ethanol}} = \frac{q}{\Delta H} = \frac{167.2}{1367} = 0.1223 \text{ mol}$

1 mark  $m_{\text{ethanol}} = n \times M_{\text{ethanol}} = 0.1223 \times 46.068$   
 $= 5.63 \text{ g (3 sig fig)}$

- (b) Write an equation for the complete combustion of ethanol.



- (c) Explain the need to monitor combustion reactions such as the combustion of petrol in cars.

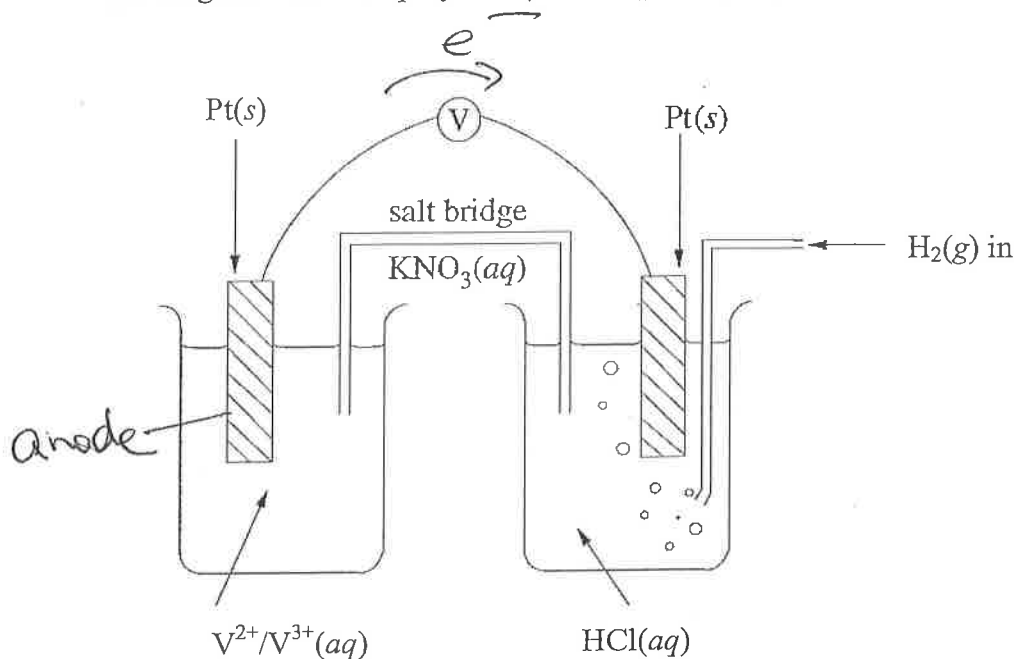
1 mark pollution related 2  
 1 mark energy/efficiency related.



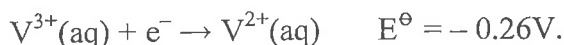
**Question 29** (4 marks)

**Marks**

The diagram below displays a Pt|V<sup>2+</sup>,V<sup>3+</sup>||H<sup>+</sup>|H<sub>2</sub>|Pt galvanic cell.



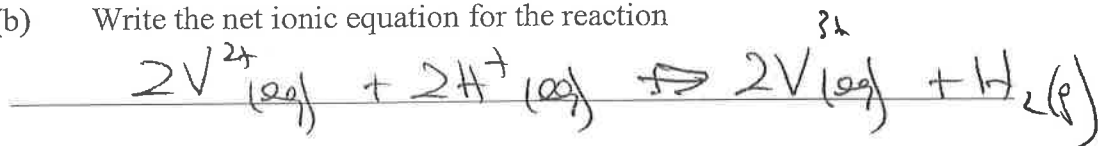
The Standard Reduction Potential for the species in the half-cell on the left is shown below:



- (a) On the diagram, clearly label the anode and the direction of electron flow.

2

- (b) Write the net ionic equation for the reaction



1

- (c) Calculate the standard cell potential for this galvanic cell.



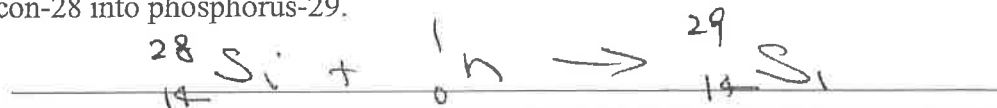
1

note: (1) anode and electron flow must be consistent for two marks. for (a)  
 (ii) consistency required for follow on mark when incorrect.

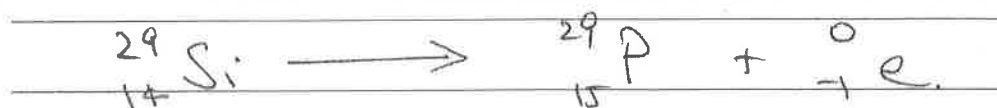
**Question 30** (2 marks)**Marks**

High quality phosphorous-doped silicon is made at the Australian Lucas Heights nuclear reactor by immersing essentially perfectly formed silicon crystals into a "neutron bath".

Write the two successive reactions that are responsible for the conversion of silicon-28 into phosphorus-29.



2



**Question 31** (4 marks)**Marks**

A student dissolves an unknown solid in water. When the resulting solution is mixed with the following solutions, the student records these observations:

Solution	Observations
barium chloride	white precipitate forms
sodium hydroxide	brown precipitate forms
lead(II) nitrate	no visible reaction

The student concludes that the unknown solid is iron(III) sulfate.

Assess the validity of the student's conclusion.

Sample answer:

- Solutions of barium chloride and iron(III) sulfate will indeed react to form a white precipitate of barium sulfate, so the student's conclusion is consistent with the first observation.
- Solutions of sodium hydroxide and iron(III) sulfate will indeed react to form a brown precipitate of iron(III) hydroxide, so the student's conclusion is consistent with the second observation.
- Solutions of lead(II) nitrate and iron(III) sulfate will react to form a white precipitate of lead(II) sulfate, so the student's conclusion is **inconsistent** with the third observation.
- The student's conclusion is therefore **invalid**.

4 marks:	<ul style="list-style-type: none"> <li>• Identifies the products of reactions that would take place between iron(III) sulfate and the given solutions and relates these to the observations</li> <li>• Assesses student's conclusion as <b>invalid</b>.</li> </ul>
3 marks:	<ul style="list-style-type: none"> <li>• As for 4 marks, but does not identify the products of all reactions or does not relate products to observations</li> </ul>
2 marks:	<ul style="list-style-type: none"> <li>• Identifies the products of two out of the three reactions that would take place between iron(III) sulfate and the given solutions and relates these to the observations</li> </ul>
1 marks:	<ul style="list-style-type: none"> <li>• Identifies the products of any reaction that would take place between iron(III) sulfate and the given solutions</li> </ul>

Notes:

- Balanced equations **including states** are an easy way to identify the products, but equations were not essential to get 4 marks.
- It was not necessary to identify what the unknown solid was in order to answer the question! A few boys tried to do this, with varying levels of success.

**Question 32** (6 marks)**Marks**

Farmer Heinz has harvested a very successful crop of beans, whereas neighbouring Farmer Stagg's crop is less impressive. Farmer Heinz says that the availability of some trace elements in soil varies with pH and suggests that their soil manganese levels might differ as a result of different soil pH.

Explain how you could use atomic absorption spectroscopy and any other relevant techniques to assess the validity of this hypothesis.

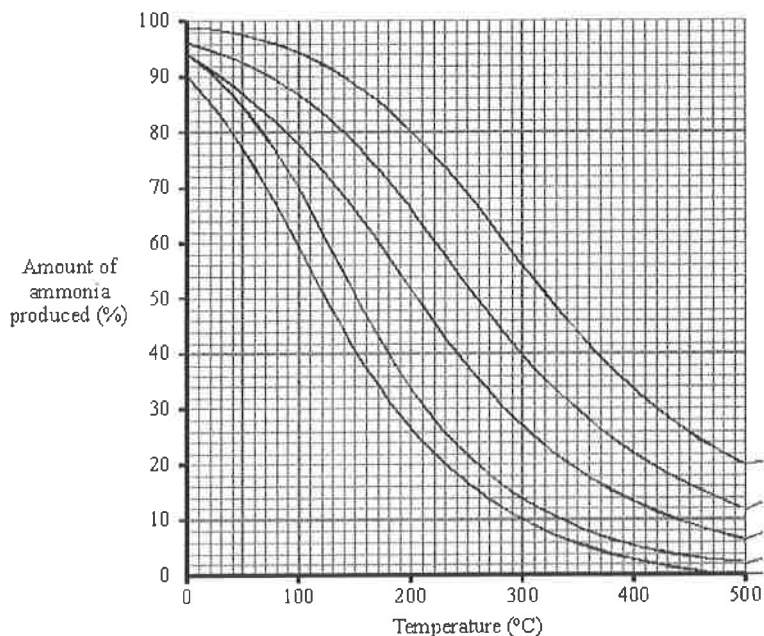
6 marks:	<ul style="list-style-type: none"> <li>• Describes a method for measuring soil manganese concentrations at both farms using AAS.             <ul style="list-style-type: none"> <li>○ Explains two or more features of AAS                 <ul style="list-style-type: none"> <li>▪ e.g. specificity of absorption, sensitivity.</li> </ul> </li> <li>○ Explains two procedures involved                 <ul style="list-style-type: none"> <li>▪ e.g. sample preparation details, instrumental details.</li> <li>▪ Must include the production of a standard curve or comparison with standard manganese solutions</li> </ul> </li> </ul> </li> <li>• Describes a method for measuring soil pH at both farms             <ul style="list-style-type: none"> <li>○ e.g. using a pH probe or indicators</li> </ul> </li> <li>• Discusses the how the results will determine whether the hypothesis will be valid or invalid.</li> </ul>
5 marks:	<ul style="list-style-type: none"> <li>• Misses one of the points required for 6 marks (often production of a standard curve or hypothesis discussion).</li> </ul>
4 marks:	<ul style="list-style-type: none"> <li>• Discusses AAS in required detail but does not mention pH.</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• Misses two of the points required for 6 marks.</li> </ul>
3 marks:	<ul style="list-style-type: none"> <li>• Any three points required for 6 marks</li> </ul>
2 marks:	<ul style="list-style-type: none"> <li>• Any two points required for 6 marks</li> </ul>
1 marks:	<ul style="list-style-type: none"> <li>• Any one point required for 6 marks</li> </ul>

Notes:

- An acid-base titration cannot be used to identify the pH of a sample. It will only give you the total acid/base content.

**Question 33** (4 marks)**Marks**

The following is a graph of percentage conversion of nitrogen and hydrogen to ammonia against temperature, for pressures between 25 and 400 atm.



- (a) On the graph, clearly label the line corresponding to a pressure of 400 atm.

1

Answer: the top curve.

- (b) With reference to the graph, explain the choice of temperature for the commercial production of ammonia.

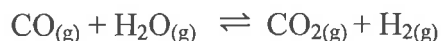
3 marks:	<ul style="list-style-type: none"> <li>Identifies a temperature of 400-600 °C.</li> <li>Explains the compromise between yield and reaction rate.</li> <li>Refers to data from the graph</li> </ul>
2 marks:	<ul style="list-style-type: none"> <li>As for 3 marks but missing identification of temperature or reference to the graph</li> </ul>
1 marks:	<ul style="list-style-type: none"> <li>Identifies a temperature of 400-600 °C or identifies compromise between yield and reaction rate.</li> </ul>

Notes:

- Some boys used the graph to predict (incorrectly) that the temperature chosen should be 200 - 300 °C.

**Question 34 (7 marks)****Marks**

- (a) The Water-gas shift reaction (WGSR) is an important industrial reaction and can be written as per below.



At 588 K, the equilibrium constant is 31.4.

- (i) Write the expression for the equilibrium constant.

**1****MARKING GUIDELINES**

Criteria	Marks
• Correctly writes the equilibrium constant expression	1

$$K = [\text{CO}_2][\text{H}_2] / [\text{CO}][\text{H}_2\text{O}]$$

Generally done well, but a few boys used '+' instead of 'x'

- (ii) The equilibrium constant decreases with an increase in temperature for this reaction. Is the forward reaction exothermic or endothermic? Justify your answer.

**2**

Marks	Marking guidelines
2	• Explains why forward reaction is exothermic based on changes to K and LCP
1	• Identifies forward reaction is exothermic

- (iii) 2.50 moles each of both  $\text{CO}_{(g)}$  and  $\text{H}_2\text{O}_{(g)}$  and 5.00 moles each of  $\text{CO}_{2(g)}$  and  $\text{H}_{2(g)}$  are added at 588 K to a 10 L vessel. Calculate the concentration of  $\text{H}_{2(g)}$  at equilibrium.

**3**

Marks	Marking guidelines
3	• Correctly calculates equilibrium concentration of hydrogen gas to be 0.636 M.
2	• As per 3 marks, less one step in calculation
1	• Identifies all equilibrium concentrations are unknown, uses unknown, x correctly, and substitutes into K expression that can be solved.

### Sample working

	CO <sub>(g)</sub>	H <sub>2</sub> O <sub>(g)</sub>	CO <sub>2(g)</sub>	H <sub>2(g)</sub>
Initial	2.5/10	2.5/10	5/10	5/10
Change	-x	-x	+x	+x
Equilibrium	0.25-x	0.25-x	0.5+x	0.5+x

$$31.4 = (0.25-x)^2 / (0.5+x)^2$$

$$\sqrt{31.4} = (0.25-x) / (0.5+x)$$

$$\sqrt{31.4} (0.5+x) = (0.25-x)$$

$$x = 0.136 \text{ M}$$

$$\text{Final concentration} = 0.5 + 0.136 = 0.636 \text{ M}$$

Many boys failed to link that there is a 1:1:1:1 relationship between all reactants and products. Some boys forgot the last step.

Many boys solved complicated quadratic when taking square root was SO much easier.

- (b) Molten sulfur is often transported to sulfuric acid plants by truck. Describe the chemistry and justify the conditions used during the industrial production of sulfuric acid from molten sulfur.

7

#### Marked holistically

Marks	Marking guidelines
7	<p>Response gives a detailed description of the production of sulfuric acid from molten sulfur.</p> <ul style="list-style-type: none"><li>Comprehensively justifies the conditions used in all four steps based on firm chemical principles including LCP, reaction rate, safety and cost considerations.</li><li>Clear, concise response with a logical progression of linked ideas.</li><li>Three relevant, linked balanced chemical equations</li></ul>
6	<ul style="list-style-type: none"><li>Missing one point from 7 marks or one incorrect piece of information.</li></ul>
4-5	<ul style="list-style-type: none"><li>Describes all four steps in the production of sulfuric acid from molten sulfur, including chemical equations.</li><li>Lists conditions necessary to achieve each step</li></ul>
2-3	<ul style="list-style-type: none"><li>Describes 2-3 relevant steps in the production of sulfuric acid from molten sulfur.</li></ul>
1	<ul style="list-style-type: none"><li>Identifies any step in the production of sulfuric acid from molten sulfur.</li></ul>

#### Notes:

- The question explicitly said 'from molten sulfur' yet many boys described the Frasch process. This was ignored.
- Nothing in question asks about transport of sulfuric acid which boys wasted time writing about. This was also ignored.
- Too many boys simply gave rote-learned answer about conditions with NO justification. Maximum marks for this was 4.
- Too many boys could not correctly recall the process at all.

(c) Compare the structure of soap with that of one specific type of detergent.

2

Marks	Marking guidelines
2	<ul style="list-style-type: none"><li>Clearly explains difference between soap and detergent showing detail knowledge of structure of both</li></ul> OR <ul style="list-style-type: none"><li>Provides simplistic difference between structure of soap and detergent AND provides detailed further relevant information on differences.</li></ul>
1	<ul style="list-style-type: none"><li>Identifies simplistic structure of soap and one other detergent.</li></ul>



**Question 34** (25 marks)**Marks**

(d) Account for the cleaning action of soap.

**3**

3 marks:	<ul style="list-style-type: none"> <li>Identifies the hydrophilic and hydrophobic nature of soap ions.</li> <li>Explains the interactions of each with non-polar/polar molecules and identifies the specific forces involved (e.g. dispersion forces, ion-dipole interactions).</li> <li>Identifies that agitation of the mixture is necessary for cleaning.</li> </ul>
2 marks:	<ul style="list-style-type: none"> <li>Identifies the hydrophilic and hydrophobic nature of soap ions.</li> <li>Explains the interactions of each with polar/non-polar molecules</li> </ul>
1 marks:	<ul style="list-style-type: none"> <li>Identifies the hydrophilic and hydrophobic nature of soap ions.</li> </ul>

(e) (i) Identify the feedstock that is common to both the Solvay process and the production of NaOH.

**1**

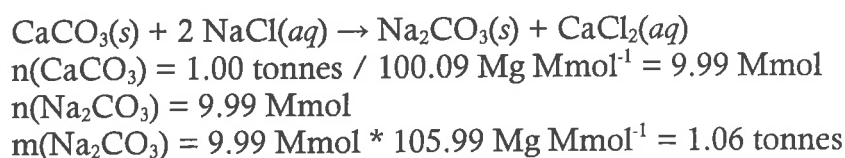
Answer: sodium chloride (or brine).

(ii) Compare the factors affecting the location of a chemical plant to produce NaOH using a mercury cell with the factors affecting the location of a chemical plant to perform the Solvay process.

**3**

3 marks:	<ul style="list-style-type: none"> <li>Compares 3 factors affecting the location of both plants, including access to raw materials and waste disposal</li> </ul>
2 marks:	<ul style="list-style-type: none"> <li>As for 3 marks but without explicit comparison</li> </ul> OR <ul style="list-style-type: none"> <li>Compares two factors affecting the location of both plants</li> </ul>
1 marks:	<ul style="list-style-type: none"> <li>Identifies a factor affecting the location of either plant</li> </ul>

(iii) Calculate the mass of the desired product of the Solvay process if 1.00 tonnes of calcium carbonate is completely used up.

**3**

Notes:

- Many boys made stoichiometry errors when using more than one equation. In this case, using the overall equation is easier.

