2003
Higher School Certificate
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your student number and/or name at the top of every page

Total Marks = 100

Section I
75 marks
This section has two parts, Part A and Part B

Part A (pages 2 – 6)
Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Part B (pages 7 – 16)
Total marks (60)
Attempt questions 16 – 27
Allow about 1 hour 45 minutes for this part

Section II (pages 17 – 24))
25 marks
Attempt ONE question from Questions 28-32
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

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Section I

Total marks (75)

Part A

Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
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STUDENT NUMBER/NAME: .....

1. Americium-241 is a radioisotope used in domestic smoke detectors. The production of this transuranic element in a nuclear reactor is represented by the equations below.

$$^{239}_{94}\text{Pu} + 2\,\text{"X"} \rightarrow {}^{241}_{94}\text{Pu} \rightarrow {}^{241}_{95}\text{Am} + \text{"Y"}$$

The names of the particles represented by the letters "X" and "Y" respectively are:

(A) neutron and electron
(B) electron and proton
(C) neutron and proton
(D) proton and electron

2. The molecular formula for 2-pentanol is:

(A) C_5H_9OH
(B) $C_5H_{12}OH$
(C) $C_5H_{10}O$
(D) $C_5H_{12}O$

3. The conditions that would most favour the fermentation of sugar include:

(A) warmth, oxygen and water
(B) warmth, no oxygen, water
(C) no warmth, no oxygen, no water
(D) warmth, oxygen, no water

4. A galvanic cell is to be constructed using Mg / Mg^{2+} and Ag / Ag^{+} two half-cells each containing a piece of the solid metal partly immersed in an aqueous solution containing ions of the same metal. The anode in this galvanic cell is:

(A) magnesium which acts as the oxidant
(B) magnesium which acts as the reductant
(C) silver which acts as the oxidant
(D) silver which acts as the reductant

5. The table below shows the heat of combustion for 4 different alcohols.

Alcohol	Mol. mass (g)	Heat of combustion(kJ mol^{-1})
methanol	32	725
ethanol	46	1364
1-propanol	60	2016
1-butanol	74	2677

The alcohol with the greatest heating value in kJ kg^{-1} is:

(A) methanol
(B) ethanol
(C) 1-propanol
(D) 1-butanol

6. Some household cleaners contain strong bases such as sodium hydroxide. A student tested household cleaning solutions with litmus and recorded the results in the following table:

Cleaning solution	Colour of blue litmus	Colour of red litmus
X	blue	red
Y	blue	blue
Z	red	red

Sodium hydroxide could be present in:

(A) X and Y
(B) X and Z
(C) Y only
(D) Z only

7. What effect would the addition of dilute hydrochloric acid have on the following equilibrium?

$$CO_{2(aq)} + H_2O_{(l)} \leftrightarrow H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

(A) The equilibrium would shift to the left, decreasing the concentration of HCO_3^-
(B) The equilibrium would shift to the right, increasing the concentration of HCO_3^-
(C) The equilibrium would not change
(D) The rate at which equilibrium is attained would be increased

8. A number of solutions were tested with a conductivity probe attached to a data logger. Which of the following solutions would record the highest conductivity reading?

(A) 0.01 mol L^{-1} HCl
(B) 0.1 mol L^{-1} HCl
(C) 0.01 mol L^{-1} CH_3COOH
(D) 0.1 mol L^{-1} CH_3COOH

9. A student used a pipette to transfer 25.0 mL of a solution to a flask. After draining the solution into the flask a small amount of solution remained in the tip of the pipette. To deliver the correct volume of solution to the flask the student should:

(A) blow the remaining solution into the flask
(B) touch the inside of the flask with the tip of the pipette
(C) shake the pipette to dislodge the remaining solution
(D) rinse the pipette with a small quantity of distilled water into the flask

10. The conjugate base of the NH_4^+ ion has the formula:

(A) NH_4OH
(B) OH^-
(C) NH_3
(D) NH_4^{2+}

11. Which of the following exhibits coordinate covalent bonding?

(A) oxygen molecule
(B) hydronium ion
(C) ammonia
(D) ethanol

12. One technique that can be used to indicate the presence of some cations in solutions is flame testing. When a platinum wire loop is placed into a solution containing barium ions, the resulting flame colour is:

(A) yellow
(B) scarlet
(C) brick red
(D) lime green

13. Atomic absorption spectroscopy was developed in Australia in the 1950s by Alan Walsh while working at CSIRO. This technique works on the principle that:

(A) glass prisms can reflect wavelengths
(B) electron beams bombard and ionise atoms
(C) gaseous atoms absorb specific wavelengths of light
(D) gaseous atoms give out specific wavelengths when excited

14. A suitable method to determine the sulfate content of a fertiliser is:

(A) acid/base titration
(B) atomic absorption spectroscopy
(C) pH measurement
(D) gravimetric analysis of a precipitate

15. The main factor that causes algal bloom in waterways is an increase in:

(A) acidity
(B) hardness
(C) phosphate concentration
(D) temperature

Section I – continued

Part B

Total marks (60)
Attempt questions 16 – 27
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

Question 16 (4 marks)

Marks

(a) Identify ONE example of an addition polymer and explain how this polymer is formed. **2**

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(b) Describe uses of this polymer in terms of its properties. **2**

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Question 17 (6 marks) **Marks**

Ethanol is widely used as a solvent. Most ethanol required for industrial use is produced using raw materials obtained from the refining of petroleum.

(a) Give the structural formula for ethanol **1**

(b) Write an equation for the production of ethanol, identifying any catalysts required. **2**

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(c) Describe and account for two uses of ethanol as a solvent. **3**

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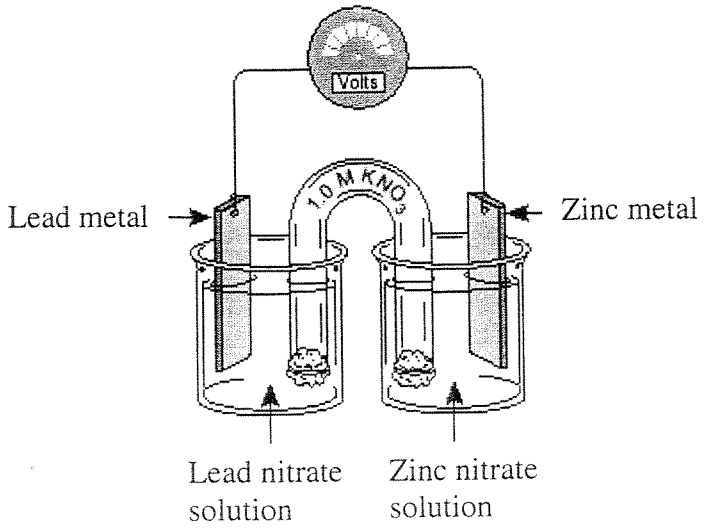
Question 18 (5 marks) **Marks**

The diagram below shows a galvanic cell.



(a) Write an ionic equation to represent the overall reaction occurring in this galvanic cell. 1

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(b) Calculate the expected voltage of this cell under standard conditions. 1

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(c) Identify one example of a galvanic cell, and evaluate the impact this cell has had on society. 3

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Question 19 (5 marks) **Marks**

(a) Identify a radioisotope which is used in medicine or industry, and describe the method used to produce this isotope. **2**

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(b) Assess the benefits and problems associated with the use of this radioisotope. **3**

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Question 20 (4 marks)

You have carried out a first-hand investigation to prepare and test a natural indicator.

(a) Outline the procedure used to prepare and test the natural indicator. **2**

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(b) Draw a table to show the results obtained in testing this indicator. **2**

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Question 21 (6 marks) **Marks**

A sample of lignite, a high sulfur content coal, was analysed and found to contain 4.32% sulphur.

(a) Calculate the volume of sulfur dioxide, at 25°C and 100 kPa, that would be produced by burning 1.0 kg of lignite coal. **3**

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(b) Assess the impact, on the environment, of using lignite as a fuel, writing equations where appropriate. **3**

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Question 22 (7 marks) **Marks**

To prepare a standard solution of sodium hydroxide a student first dissolved 1.0 g of solid sodium hydroxide in 250 mL of distilled water. By titration, 25.0 mL of this solution required 23.2 mL of standard 0.100 mol L^{-1} hydrochloric acid for neutralisation.

(a) Why is titration necessary to standardise the sodium hydroxide solution? **1**

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(b) Calculate the concentration of the standardised sodium hydroxide solution. **2**

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(c) Describe the titration procedure for this standardisation. **4**

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STUDENT NUMBER/NAME: .....

Question 23 (4 marks) **Marks**

During your practical work you performed a first hand investigation to prepare an ester.

(a) Identify an ester by name and draw its structural formula. **2**

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(b) Explain the need for refluxing in this investigation. **2**

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Question 24 (3 marks)

Define the term *buffer* in relation to acid-base systems and describe ONE example of buffer action in a natural system. **3**

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Question 25 (6 marks) **Marks**

The table below gives the concentration in parts per million, of some substances found in Sydney's tap water, along with the National Health and Medical Research Council (NHMRC) guidelines for maximum safe concentrations of these substances.

Substances	**Concentration in ppm in Sydney tap water**	**NHMRC guidelines concentration ppm**
Total dissolved solids	86	1000
Calcium ion	15	200
Chloride ion	19	400
Nitrate ion	0.4	12

(a) Describe a chemical test you could perform to test for the presence of chloride ion. 1

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(b) Identify a possible source of nitrate ion in the tap water. 1

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(c) Identify one other substance which can affect water quality, and describe an adverse effect if this substance is at too high a concentration. 2

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(d) Sydney tap water has chlorine added in varying concentrations. Discuss the purpose of adding this chlorine. 2

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STUDENT NUMBER/NAME: .....

Question 26 (7 marks) **Marks**

The Haber Process is used in the synthesis of ammonia from gaseous hydrogen and nitrogen. The percentage conversion to ammonia at different temperatures and pressures is shown in the table below.

Temperature °C	Percentage conversion to ammonia at pressures indicated		
	250 atm	500 atm	1000 atm
150	94	97	99
350	44	74	83
550	12	28	34
750	6	14	17

(a) Write the equation for the Haber process. **1**

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(b) Justify whether the reaction is endothermic or exothermic. **2**

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(c) Analyse the effect of increasing pressure on this system. **2**

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(d) Justify the use of high pressure and a temperature of 300-400 °C in the industrial synthesis of ammonia. **2**

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STUDENT NUMBER/NAME: .....

Question 27 (3 marks) **Marks**

The water in Sydney is very soft, but the water in Broken Hill is hard.

(a) Identify the cause of water hardness. **1**

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(b) Describe how you could quickly tell if a sample of water came from Sydney or Broken Hill. **2**

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End of Section I

STUDENT NUMBER/NAME: .....

Section II

Total marks (25)

Attempt ONE question from Questions 28 – 32
Allow about 45 minutes for this part

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

STUDENT NUMBER/NAME: .....

Question 28 – Industrial Chemistry (25 marks) **Marks**

(a) A chemist performed three separate experiments to analyse the following equilibrium system:

$$\underset{\text{(colourless)}}{H_{2(g)}} + \underset{\text{(purple)}}{I_{2(g)}} \Leftrightarrow \underset{\text{(colourless)}}{2HI_{(g)}}$$

The forward reaction is endothermic, requiring 52 kJ mol^{-1}

All three experiments were carried out at the same pressure. Two of the experiments were carried out at the same temperature while the other was carried out at a different temperature.
The results of the experiments are shown in the table below.

Experiment	Concentration (mol L^{-1})					
	Initial			At equilibrium		
	$H_{2(g)}$	$I_{2(g)}$	$HI_{(g)}$	$H_{2(g)}$	$I_{2(g)}$	$HI_{(g)}$
1	1.000	1.000	0.000	0.228	0.228	1.544
2	1.000	2.000	3.000	0.526	1.526	3.948
3	0.000	0.625	0.750	0.0175	0.643	0.715

(i) Determine whether the experiment carried out at the DIFFERENT temperature was at a higher or lower temperature than that of the other two experiments. Explain your answer. **2**

(ii) Describe how the chemist could visually monitor the time when Experiment 1 reached equilibrium. **1**

(iii) After Experiment 1 reached equilibrium, the chemist doubled the concentration of H_2 and maintained a constant temperature.
Describe what would happen in the reaction vessel in response to this change and the effect this would have on the value of the equilibrium constant. **2**

(b) Outline a first-hand investigation you have carried out to saponify an oil or fat, including the method used to test the product. **4**

(c) Almost all of the sulfuric acid produced is made by the Contact process.

(i) The first stage in the Contact process involves the production of sulfur dioxide where liquid sulfur is sprayed into a combustion furnace where it burns in air at 1000°C. Write an equation to show the formation of sulfur dioxide. **1**

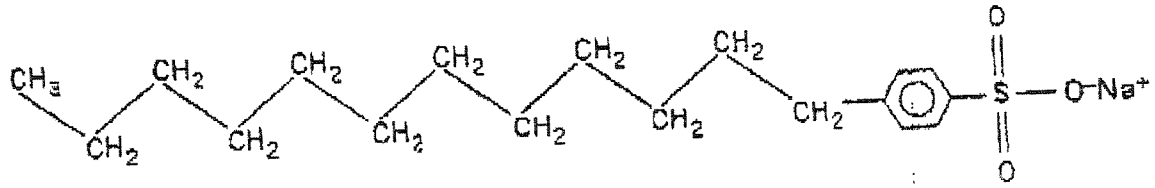
(ii) Identify the source of the sulfur. **1**

(iii) Describe ONE specific use of sulfuric acid in industry. **1**

Question 28 – Industrial Chemistry continues on next page

Question 28 (continued) **Marks**

(d) The diagram below shows the structure of a typical synthetic detergent molecule.



Distinguish between common soaps and synthetic detergents in terms of their chemical composition, structure of the molecule and their use as cleaning agents. 3

(e) The equations below represent four of the steps in the production of sodium carbonate by the Solvay process but they are not in the correct sequence.

Step 1 $Ca(OH)_{2(s)} + 2NH_4Cl_{(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)} + NH_{3(g)}$

Step 2 $2NaHCO_{3(s)} \xrightarrow{heat} Na_2CO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$

Step 3 $CaCO_{3(s)} \xrightarrow{heat} CaO_{(s)} + CO_{2(g)}$

$NaCl_{(aq,\ impure)} \xrightarrow{fractional\ crystallisation} NaCl_{(s,\ pure)}$

Step 4 $H_2O_{(l)} + NaCl_{(aq)} + CO_{2(g)} + NH_{3(g)} \longrightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$

(i) Write the steps in the correct sequence that they occur in the Solvay process. 2

(ii) Name the chemicals that are recycled during the Solvay process. 2

(f) The processes of industrial chemistry have enabled scientists to develop replacements for natural products.

Identify and discuss the issues associated with the increased need for a natural resource that is not a fossil fuel and evaluate the progress made to solve the problems identified. 6

End of Question 28

NSW INDEPENDENT TRIAL EXAMS – 2003
HSC CHEMISTRY - SUGGESTED ANSWERS

PART A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	D	B	B	D	C	A	B	B	C	B	D	C	D	C

PART B.

16. (a) eg., polyethylene which is made by heating ethylene monomer with a suitable catalyst, so that the electrons from the ethylene double bond link ethylene molecules into long strands 2
    (b) the weak dispersion forces between the polymer strands yield a soft and flexible plastic which is easily moulded, making it suitable for food containers, plastic bags and plastic film for food wrapping. 2
17. (a) CH_3CH_2OH or expanded formula 1
    (b) $C_2H_{4(g)} + H_2O \rightarrow C_2H_5OH$ The catalyst can be sulfuric or phosphoric acid 2
    (c) Ethanol is a polar molecule with an OH group providing hydrogen bonding. Thus it is a good solvent for other polar organic molecules, including lacquers, dyes, perfumes and food flavourings. It also is fully soluble in water, as in alcoholic drinks. 3
18. (a) $Zn_{(s)} + Pb^{2+} \rightarrow Zn^{2+} + Pb_{(s)}$ 1
    (b) Cell voltage = 0.76 – 0.13 = 0.63 V 1
    (c) eg., the dry (Leclanche) cell which has widespread use, providing a cheap source of power for nightime illumination, in electric torches, and for many portable electronic devices such as radios, CD players and toys. Disadvantages include its bulk, limited shelf life and possible leakage causing damage to equipment. 3
19. (a) eg., ^{99}Tc is made using neutrons from a reactor to bombard ^{98}Mo. After absorption of the neutron the Mo nucleus emits a beta particle, forming ^{99}Tc 2
    (b) This isotope is used in medicine to trace the blood flow in the body, for example in the retina of the eye, allowing diagnosis of damaged blood vessels. It has a very short half-life, so must be used immediately, but this also limits the radiation exposure of the patient. As with all radioisotopes some tissue damage occurs from its gamma radiation. 3
20. (a) The leaves were chopped into small pieces, and placed in hot water to extract the purple dye. The solution was decanted and allowed to cool. A range of solutions was tested by adding a few drops of the cabbage dye to each. 2
    (b)

Subtance	water	ammonia soln.	vinegar	drain cleaner
Dye Colour	blue	green	red	yellow

    2
21. (a) Moles of sulfur = 43.5/32 = 1.35 mol
    Moles of SO_2 formed = 1.35 mol
    Volume of SO_2 formed = 1.35 x 24.79 = 33.47 L 3
    (b) Combustion of the lignite releases SO_2 into the atmosphere. This gas causes breathing difficulties for some people. It also undergoes oxidation to SO_3 which dissolves in rainwater to form sulfuric acid. Acid rain causes many problems including corrosion of metals and building materials, damage to plants and aquatic systems such as freshwater lakes and release of heavy metals by accelerated weathering of rocks. 3
22. (a) sodium hydroxide absorbs both water and carbon dioxide from the air, so that it cannot be used as a primary standard. Titration is needed to determine its concentration. 1
    (b) [NaOH] = 23.2 x 0.100/25.0 = 0.0928 mol L^{-1} (mole ratio HCl:NaOH = 1:1) 2

Q22 (c) Titration procedure to include use of pipette for NaOH solution, burette for HCl, conical flask and suitable indicator such as phenolphthalein. All glassware to be rinsed with distilled water, followed by the solutions for the pipette and burette. 2
Titration carried out with swirling of flask contents, with the end point recorded as the volume of HCl to decolorise the indicator. Rinse flask with distilled water after each titration.
Minimum of three titration measurements, with two agreeing within 0.1 mL. 2

23. (a) eg., ethyl acetate (ethanoate) $CH_3CH_2OCOCH_3$ or expanded structural formula 2
(b) The reaction is slow and requires and is carried at by boiling with a catalyst. As the reactants and product are volatile, and highly flammable, a reflux condenser is needed to continuously condense the escaping vapour and return the condensate to the reaction flask. 2

24. A buffer is a solution which maintains almost constant pH when small quantities of acid or base are added. The buffer consists of a weak acid and its conjugate base, at roughly equal concentrations.
An example is our blood, which is buffered by the presence of the hydrogen carbonate ion, maintaining a stable pH as it circulates though the body. 3

25 (a) Add a few drops of dilute silver nitrate solution. If chloride ion is present a white ppte. of AgCl forms. 1
(b) Nitrate ion may come from run-off from gardens and farms that have had nitrate fertiliser applied. 1
(c) eg., sodium ion, which causes health problems in drinking water, including increasing blood pressure and the risks of circulatory diseases. 2
(d) The chlorine acts as a disinfectant by destroying bacteria and other microbes, including those which can cause diseases such as cholera, typhoid and dysentery. 2

26. (a) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ 1
(b) The data in the table show that increasing the temperature reduces the equilibrium concentration of ammonia, forcing the equilibrium to the left. Hence the forward reaction is exothermic. 2
(c) Increasing pressure increases % ammonia yield, at all temperatures. This is confirmed by the stoichiometry of the reaction with 4 moles of gaseous reactants forming 2 moles of gaseous products –hence an increase in pressure favours the side of fewer gaseous molecules. 2
(d) High pressure increases the equilibrium yield of ammonia. A temperature of 300-400 deg. is a compromise to establish equilibrium quickly, and still obtain an acceptable yield of ammonia. 2

27. (a) The presence of a relatively high concentration of calcium and/or magnesium ions. 1
(b) Either test the lathering qualities of the water with soap, which will form a non-lathering scum (precipitate) with hard water, or add carbonate ions, which form a white ppte. of $CaCO_3$ with Ca^{2+} ion. 2

Section II Options:

Q28. Industrial Chemistry

(a) (i) The equilibrium constants ($k = [HI]^2/[H_2][I_2]$ are:
Exp 1 = 45.9, Exp 2 = 19.4, Exp 3 = 45.4
Experiments 2 was carried out at a lower temperature, as the forward reaction is endothermic, meaning that K decreases with decreasing temperature. 2

(ii) Observe the purple colour (iodine gas) of the mixture. When the intensity is constant the system is at equilibrium. 1

(iii) The equilibrium moves to the right, increasing [HI]. The value of K is the same. 2

(b) A mixture of sodium hydroxide solution and olive oil is maintained at its boiling point for about 20 minutes, or until the oil layer has dissolved. After cooling, concentrated salt solution is added to precipitate the soap, which is separated and washed in a little water. The soap is tested by shaking a small amount in a test tube of water, to observe its lathering effect. 4

(c) (i) $S(g) + O_2(g) \rightarrow SO_2(g)$ 1

(ii) The sulfur is mined from natural deposits by the Frasch process. 1

(iii) eg., in making detergents, superphosphate, explosives etc. or as battery electrolyte 1

(d) Synthetic detergents use the SO_3^- as the hydrophilic part of the molecule, while soaps contain the carboxyl COO^- group. Soaps are ineffective in hard water as they form an insoluble precipitate with calcium or magnesium ions. Synthetic detergents do not form a precipitate and so are effective for cleaning in hard water. 3

(e) (i) 3,4,2,1 2

(ii) carbon dioxide and ammonia 2

(f) eg., natural rubber (latex) is collected as sap from bark of rubber trees. The supply of latex is inadequate to meet the huge demand for rubber, for auto tyres, and can be interrupted by political upheavals.

Synthetic rubber has largely replaced latex. As an addition polymer based upon styrene and butadiene, synthetic rubber has many advantages over the natural product. With fewer double bonds in the vulcanised product it deteriorates more slowly. By modifying the side groups on the polymer chain a variety of rubbers with specialised properties has been obtained. for example, in neoprene, the use of Cl atoms in place of methyl groups yields a strong, flexible and chemical resistant rubber. 6