NEAP CHEMISTRY TRIAL 2006

1. What is the systematic name for the monomer from which polyvinyl chloride is built?

(A) chloroethene
(B) 1,1-dichloroethene
(C) 1,2-dichloroethene
(D) vinyl chloride

2. Consider the following standard reduction potentials:

Half-reaction	*E° (V)*
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	–2.87
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	–0.13
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$Ag^{1+} + e^- \rightleftharpoons Ag$	+1.80

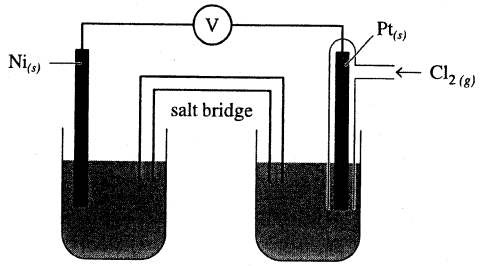
Using the above table, which of the following metals is the strongest REDUCING AGENT?

(A) Ca
(B) Pb
(C) Cu
(D) Ag

3. In which of the following does the nitrogen have an oxidation state of +4?

(A) HNO_3
(B) NO_2
(C) N_2O
(D) NH_4Cl

4. Consider the following diagram.



Which of the following describes what happens to the concentrations of Ni^{2+}, Cl_2 and Cl^- and the masses of the Ni and Pt electrodes as this galvanic cell spontaneously generates an electric current at 25°C and 100 kPa?

	Concentration of Ni^{2+}	*Concentration of Cl_2*	*Concentration of Cl^-*	*Mass of Ni electrode*	*Mass of Pt electrode*
(A)	decreases	increases	increases	increases	decreases
(B)	increases	decreases	increases	decreases	increases
(C)	decreases	no change	no change	increases	no change
(D)	increases	decreases	increases	decreases	no change

5. Carbon-14 radioactively decays via the emission of a beta particle. Which of the following is the product nuclide of this decay?

(A) boron-13
(B) carbon-13
(C) carbon-14
(D) nitrogen-14

6. Which of the following substances would NOT be present in the reaction flask during the preparation of ethyl propanoate?

(A) ethanoic acid
(B) ethanol
(C) propanoic acid
(D) sulfuric acid

7. An unknown solution is tested with four indicators to determine its pH. The table below shows the results obtained.

Indicator	*Acidic colour*	*pH range*	*Basic colour*	*Colour in unknown solution*
methyl orange	red	3.1 – 4.4	yellow	yellow
bromothymol blue	yellow	6.0 – 7.6	blue	green
phenol red	yellow	6.4 – 8.0	red	orange
phenolphthalein	colourless	8.3 – 10.0	bright pink	colourless

Which of the following statements gives the best range for the pH of the solution?

(A) The solution has a pH less than 8.3.
(B) The solution has a pH between 6.0 and 8.0.
(C) The solution has a pH between 6.4 and 7.6.
(D) The solution is neutral (pH = 7).

8. Which of the following species could best be described as amphiprotic?

(A) HNO_3
(B) NH_2^-
(C) $H_2PO_4^-$
(D) CH_3COO^-

9. Before carrying out a titration between acetic acid, CH_3COOH, and potassium hydroxide, KOH, the equipment must be rinsed appropriately.

If the acid is to be dispensed from the burette, which of the following indicates the best rinsing procedure?

	Burette	*Pipette*	*Conical flask*
(A)	rinsed with CH_3COOH	rinsed with H_2O	rinsed with KOH
(B)	rinsed with H_2O	rinsed with KOH	rinsed with H_2O
(C)	rinsed with H_2O	rinsed with H_2O	rinsed with KOH
(D)	rinsed with CH_3COOH	rinsed with KOH	rinsed with H_2O

10. During an experiment, a student measures the pH of a 0.01 mol L^{-1} solution of citric acid to be 3.6, but the pH of a 0.01 mol L^{-1} solution of hydrochloric acid is 2.0.

What is the most likely reason for this difference in pH?

(A) Citric acid is a stronger acid.
(B) Hydrochloric acid is a stronger acid.
(C) Citric acid is triprotic.
(D) Hydrochloric acid is more concentrated.

11. Which of the following substances would be least suitable for analysis by atomic absorption spectroscopy?

(A) iron
(B) sodium
(C) nitrogen
(D) potassium

12. A student wished to analyse the sulfate content of a lawn fertiliser. Which of the following would be the best reagent to add to a solution of the fertiliser to perform a gravimetric analysis?

(A) iron sulfate
(B) sodium sulfate
(C) barium carbonate
(D) barium chloride

13. The following table compares some properties of gaseous oxygen and the oxygen free radical. Which alternative best fits the correct descriptions?

	Gaseous oxygen		*Oxygen free radical*	
(A)	less reactive	monatomic	more reactive	molecular
(B)	less reactive	molecular	more reactive	monatomic
(C)	more reactive	monatomic	less reactive	molecular
(D)	more reactive	molecular	less reactive	monatomic

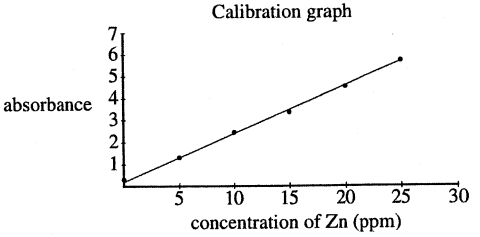
14. Microscopic membrane filters may be used as an alternative to chemical treatment of water. Which of the following is the best reason to use these filters?

(A) To remove harmful heavy metals.
(B) To remove large particulate matter.
(C) To remove fluoride and chloride.
(D) To remove harmful microorganisms.

15. A sample of water was collected downstream from a factory producing batteries. The sample was analysed for zinc content using the following method.

- Standard solutions of zinc were used to prepare a calibration curve.
- One litre of river water was collected.
- A 100 mL sample of this water was diluted to 1 L using distilled deionised water.
- A 50 mL sample of the dilute solution was used to aspirate into an atomic absorption spectrometer.

The following graph was obtained using standard solutions of zinc nitrate.



The absorbance reading of the 50 mL sample of the diluted river water was 1. Which of the following is closest to the concentration of zinc in the original river water sample?

(A) 10 ppm
(B) 40 ppm
(C) 50 ppm
(D) 100 ppm

Section I (continued)

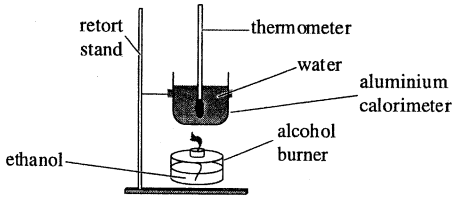
Part B

Total marks 60
Attempt Questions 16–27.
Allow about 1 hour and 45 minutes for this part.

Answer Part B questions in the spaces provided.
Show all relevant working in questions that require calculations.

Question 16 (6 marks) — Marks

A student assembled the following equipment in order to determine the molar heat of combustion of ethanol.



Experimental results found that the temperature of 100 mL of water increased from 18°C to 58°C on burning 0.76 g of ethanol.

(a) Define the term *molar heat of combustion*. **1**

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(b) Write a balanced chemical equation to show the complete combustion of ethanol. **1**

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(c) Calculate the molar heat of combustion of ethanol based on the experimental results. **2**

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(d) Explain how this calculated value would compare to the theoretical value. **2**

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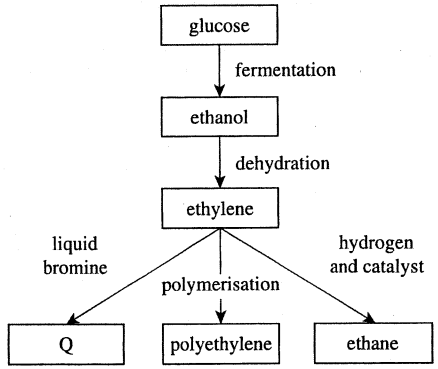
Marks

Question 17 (4 marks)

The following flow diagram shows a series of reactions.



(a) Draw a structural equation to illustrate the production of Q. **1**

(b) Ethylene can be readily converted into ethane. Give a reason for the presence of a catalyst in this reaction. **1**

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(c) Polyethylene can be used as a cling film. Describe this use in terms of its properties. **2**

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Marks

Question 18 (3 marks)

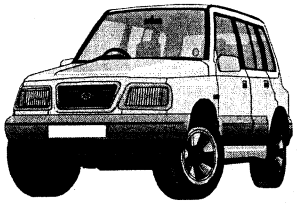
On February 1, 2004, the synthesis of the transuranic elements ununpentium (Z = 115) and ununtrium (Z = 113) was reported by Russian and American scientists.

Describe how transuranic elements such as ununpentium and ununtrium may be synthesised and identify ONE safe practice which must be adopted when working with radioactive elements such as these. **3**

Marks

Question 19 (5 marks)

A new vehicle is said to combine hybrid electric power with the capability of operating on a mixture of 15 per cent petrol and 85 per cent ethanol.



Evaluate the likelihood of the success of ethanol as an alternative fuel. **5**

Marks

Question 20 (6 marks)

Although the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur, the levels of these oxides have been increasing since the industrial revolution.

It has been observed that the pH of rainwater is lower near significant sources of these gases.

(a) Account for the increasing concentration of oxides of nitrogen (NO_x) in the atmosphere. **2**

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(b) Explain the formation of acidic solutions from oxides of nitrogen and evaluate reasons for concern about the effects of acid rain. **4**

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Question 21 (3 marks)

During the HSC Chemistry course you performed a first-hand investigation in which you identified the pH of a variety of salt solutions. If solutions of NH_4Cl and Na_2CO_3 were used in this task, predict the acidic, basic or neutral nature that you would identify. Justify your prediction, including relevant equations in your answer. **3**

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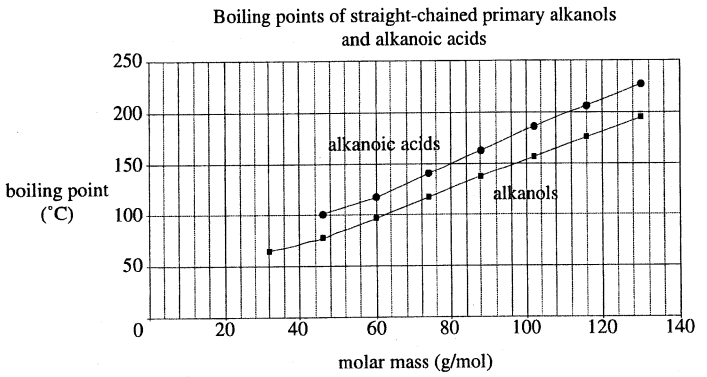
Marks

Question 22 (5 marks)



(a) Using the graph above, explain the trend observed in the boiling points for molecules of the same molar mass. **3**

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(b) Many products found in the supermarket contain acids or esters. Some of these are extracted from natural resources but an increasing number are being synthetically prepared. **2**

Providing specific examples, outline the use of acids and esters in food products.

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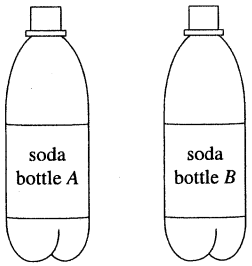
Marks

Question 23 (4 marks)

The following results were obtained during an investigation involving the decarbonation of two bottles of soda water. Each bottle was opened for a 24-hour period before re-sealing.



	bottle *A*	bottle *B*
Initial mass of sealed bottle (g)	125.5	125.5
Final mass of sealed bottle (g)	125.1	124.8
Change in mass (g)	0.4	0.7
Room conditions	cold	warm
Volume of CO_2 released at 25°C and 100 kPa (mL)	225.3	

(a) Calculate the volume of carbon dioxide (CO_2) gas lost from bottle *B* at 25°C and 100 kPa. **1**

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Question 23 continues on page 14

Marks

Question 23 (continued)

(b) In each bottle the following equilibrium process exists:

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + \text{heat}$$

Explain the difference in the volume of carbon dioxide lost from the two bottles in terms of Le Chatelier's Principle. **3**

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Question 24 (4 marks)

It is well known that safety glasses should always be worn during practicals involving acids since spills and splashes can occur. The corrosive nature of acids can damage workbenches or pose a risk to people working in the lab.

A handbook for risk assessment states:

'To minimise risk, large acid spills should be neutralised with lime ($CaCO_3$) before mopping up.'

Assess this recommended method. **4**

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Marks

Question 25 (5 marks)

'Good up high, bad down low' is a statement which has often been made in reference to atmospheric ozone.

(a) Explain this statement. **3**

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(b) Use Lewis electron dot structures to demonstrate the formation of the bonds in an ozone molecule. **2**

Marks

Question 26 (4 marks)

A student was given a sample of an unknown soluble salt. She suspected the sample contained barium ions. Describe the procedures she may have used to confirm her suspicion. Include at least one precaution taken to minimise risk. **4**

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Marks

Question 27 (5 marks)

Lake Upyajumpa is located in a highly-developed farming region and has a factory that utilises the lake's water in the production of steel.

A sample was taken from Lake Upyajumpa and tested for water quality. Two of the results obtained were:

Dissolved oxygen (DO):	3 mg L^{-1}
Biological oxygen demand (BOD):	4.1 mg L^{-1}

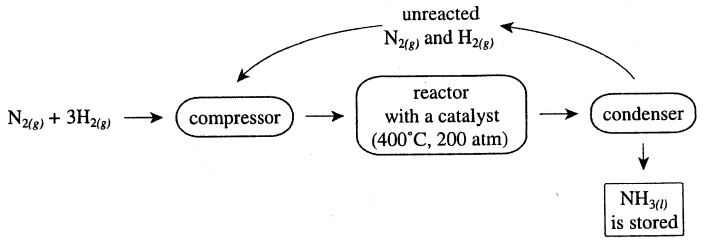
The reading obtained for DO was very low and vertebrate life within the lake would be in danger. The BOD value was borderline to indicating the lake was polluted.

Analyse the impact that the local community may have had which could have lead to the results of DO and BOD obtained. **5**

Marks

Question 28 (6 marks)

In a modern ammonia-producing plant many factors need to be monitored carefully. The following diagram describes the main features of such a plant:



In this production plant, the pressure and temperature are closely monitored for the combination of the reactant gases (in the reactor) and for the removal of the product (in the condenser).

Explain why the temperature and pressure must be carefully monitored in these chambers. Use appropriate equations to illustrate your answer. **6**

Question 29 — Industrial Chemistry (25 marks)

Marks

(a) (i) Identify the products of the Solvay process. **1**

(ii) Explain the importance of ammonia in the Solvay process using appropriate equations. **3**

(b) The chlor-alkali industry is one of the largest in developed countries. It produces chlorine, hydrogen and sodium hydroxide on a commercial scale by an electrolytic process. Analyse the chlor-alkali industry's choice of concentrated salt water (brine) for electrolysis, rather than molten sodium chloride or dilute sodium chloride. **7**

(c) Soaps and detergents are both cleaning agents.

(i) Draw structural diagrams to distinguish between a soap and a cationic detergent. **2**

(ii) List two different uses of both the soap and the cationic detergent. **2**

(iii) Account for one of the uses of either the soap or the cationic detergent by specific reference to the soap's or detergent's structure. **3**

(d) Sulfuric acid is produced commercially using the contact process but it may be modelled in the laboratory. One important step is the production of SO_3 according to:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad \Delta H = -196 \text{ kJ mol}^{-1}$$

(i) In one laboratory preparation of SO_3 carried out in a 2 L reaction flask the number of mole of SO_2, O_2 and SO_3 were 0.224, 0.136 and 0.414 respectively at equilibrium. Calculate the value of the equilibrium constant for this reaction. **2**

(ii) Discuss the relationship between rate of reaction and equilibrium conditions with reference to the production of SO_3. **5**

Section I

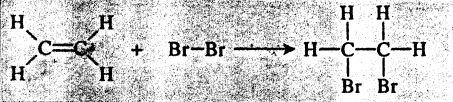
Part A

Answer and explanation	Syllabus content and course outcomes
Question 1 A The systematic name for the monomer from which polyvinyl chloride is built is chloroethene. Vinyl chloride is the common name for this species, and answers B and C give names for structures containing two Cl atoms (not one).	9.2.1 H9
Question 2 A The strongest reducing agent is most easily oxidised and therefore most difficult to reduce (lowest reduction potential on the table).	9.2.4 H7, H8, H14
Question 3 B The oxidation state of nitrogen in A is +5, in C it is +1 and in D it is –3. Only in NO_2 is it +4.	9.2.4 H6
Question 4 D The reactions occurring in this cell are: $Ni \rightarrow Ni^{2+} + 2e^-$ at the anode (nickel electrode); $Cl_2 + 2e^- \rightarrow 2Cl^-$ at the cathode (platinum electrode). Thus, over time the Ni electrode decreases in mass and the concentration of Ni^{2+} ions increases. The concentration of Cl_2 decreases and the concentration of Cl^- increases. The platinum electrode is unaffected.	9.2.4 H7, H8, H14
Question 5 D A beta particle is an e^-. The decay process occurring is: $^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$ So the product is nitrogen-14.	9.2.5 H6
Question 6 A The production of ethyl propanoate occurs as follows: ethanol + propanoic acid $\overset{\text{conc. } H_2SO_4}{\rightleftharpoons}$ ethyl propanoate + water	9.3.5 H9
Question 7 C MO indicates that the solution has pH > 4.4 BB indicates that the solution has 6.0 < pH < 7.6 PR indicates that the solution has 6.4 < pH < 8.0 Ph indicates that the solution has pH < 8.3 Altogether, it can be determined that 6.4 < pH < 7.6	9.3.1 H10, H13, H14
Question 8 C Amphiprotic substances have the ability to donate a proton (act as acid) and to accept a proton (act as base): $H_2PO_4^- + HCl \rightleftharpoons H_3PO_4 + Cl^-$ $H_2PO_4^- + OH^- \rightleftharpoons HPO_4^{2-} + H_2O$ HNO_3 can only donate a proton, NH_2^- and CH_3COO^- can only accept a proton.	9.3.4 H8, H10

Part A (Continued)

Answer and explanation	Syllabus content and course outcomes
Question 9 D A burette is always rinsed with the solution it is going to dispense. A pipette is always rinsed with the solution it is going to dispense. A conical flask is always rinsed with water before use (or is clean and dry).	9.3.4 H11, H12
Question 10 B HCl is monoprotic, citric acid is triprotic. HCl is a strong acid, citric acid is a weak acid. Concentration of 0.01 $molL^{-1}$ is the same for each. pH of 2 for HCl implies $[H^+] = 0.01$ $molL^{-1}$ pH of 3.6 for citric acid implies $[H^+] = 2.5 \times 10^{-4}$ $molL^{-1}$ A higher pH means fewer H^+ ions in solution and less ionisation of the acid. Less ionisation means a weaker acid.	9.3.3 H8, H10, H13
Question 11 C AAS is most suited to ions of metallic elements. Nitrogen is the only non-metal in the list.	9.4.3 H4, H6
Question 12 D The SO_4^{2-} ions in the lawn food solution need to be precipitated out as $BaSO_4$. A solution of Ba^{2+} ions needs to be added. The compounds in A and B don't contain barium at all. Barium carbonate is insoluble and cannot be added as a solution.	9.4.3 H8, H11, H13
Question 13 B Gaseous oxygen is O_2. It is molecular and relatively less reactive than monatomic O atoms (oxygen free radicals), which contain reactive unpaired electrons.	9.4.4 H7, H8
Question 14 D Microscopic membrane filters are very fine-pored to remove microscopic-sized impurities (microorganisms). They are not suitable for large particulate matter. The pores are not small enough to trap ions such as fluoride and chloride or heavy metals effectively. Also, clean water at the end of the treatment process should still contain fluoride and chloride since they were additives included for specific purposes.	9.4.5 H3, H4, H5
Question 15 B An absorbance reading of 1 corresponds (approximately) to a Zn concentration of 4 ppm. The sample tested is one-tenth the concentration of river water, so the Zn concentration in river water is (approximately) 40 ppm.	9.4.3 H10, H13, H14

Part B

Sample answer	Syllabus content, course outcomes and marking guide
Question 16	
(a) The amount of heat released when one mole of a substance is completely combusted (burnt in sufficient oxygen) at constant temperature and pressure to produce carbon dioxide and water.	9.2.3 H7, H8, H13 • Correctly defines the molar heat of combustion. 1
(b) $C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$	9.2.3 H9, H10, H13 • Correctly writes the balanced equation . . 1
(c) $q = m \times C \times \Delta T$ $= 100 \times 4.18 \times 40 = 0.1 \times 4.18 \times 10^3 \times 40$ $= 16720$ J $\Delta H = -q \div \frac{m}{M}$ $= -16720 \div \frac{0.76}{46.068}$ $= -1013496$ J/mol $= -1013.5$ kJ/mol	9.2.3 H8, H10, H13 • Correctly calculates the heat transferred to water • Correctly calculates the molar heat of combustion of ethanol (with negative sign) . . . . . 2 • Correctly calculates the heat transferred to water and the molar heat of combustion **without** negative sign OR • Correctly calculates the heat transferred to water only OR • Correctly calculates the molar heat of combustion of ethanol (with negative sign) 1
(d) The calculated value is probably lower than the theoretical value. Heat could be lost to the container and/or the surrounding environment; combustion may be incomplete (indicated by a build-up of soot on the base of the container); or some heat may have also been used to evaporate the water in the container.	9.2.3 H7, H8 • States that the calculated value would be lower than the theoretical value • Provides a clear explanation to account for this difference. . . . . 2 • States that the calculated value would be lower than the theoretical value OR • Provides a clear explanation to account for this difference OR • States that the calculated value would be lower than the theoretical value and gives a vague explanation 1
Question 17	
(a) 	9.2.1 H9 • Draws a correct structural equation 1
(b) The purpose of the catalyst is to speed up the rate of reaction (conversion of reactants to products) by lowering the activation energy. The catalyst remains in (or returns to) its original form at the end of the reaction.	9.2.1 H7, H8 • States a clear reason for the presence of the catalyst 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(c) Cling films are made from low-density polyethylene (LDPE).	9.2.1 H3, H4, H13 • Identifies several properties of LDPE • Clearly relates two or more properties to the use of the product. . . . . 2 • Identifies some properties of LDPE AND • Clearly relates one property to the use of the product 1

Property of LDPE	Suitability of property to use
Very flexible	Allows for it to be easily wrapped around items
Excellent cling properties	It can easily cling to itself
Transparent (fewer crystalline regions)	Better visibility of items that have been wrapped
Impermeable to water and resistant to most chemicals (including oil and grease)	Useful for sealing – keeps food crisp, prevents leakage, etc.
Melting point of approximately 115°C	Can be used to cover food that requires defrosting
Good elastic recovery and puncture resistance	Resistant to handling – retains toughness and pliability over a wide temperature range

Sample answer	Syllabus content, course outcomes and marking guide
Question 18	9.2.5 H1, H3, H6, H13
Transuranic elements can be made by bombarding heavy nuclei such as uranium, plutonium, americium or lead, with high speed particles such as electrons, neutrons, small nuclei (helium or carbon nuclei) or even ions. Ununtrium (Z = 113) and ununpentium (Z = 115) were made by bombarding americium-243 with calcium-48 ions in a cyclotron. Safe practices: • Radioactive materials must always be stored in containers that are well shielded. You must never handle these materials with bare hands. • People who use radioactive materials must be well-trained to handle such things in a safe manner. • People must wear appropriate safety clothing which, depending in the radioactive isotope in use, may vary from gloves and face mask to specially laundered laboratory coats and overshoes, lead-lined aprons and, in the extreme, full protective suits. • People working in an around radiation facilities must wear radiation monitors (badges) that records the total amount of radiation they receive. • Proper procedures for safe storage and disposal of radioactive wastes must be established. • Clear signs must be displayed in any location where radiation equipment or materials are being used or stored.	• Correctly describes how transuranic elements may be synthesised and identifies ONE safe practice that must be adopted when working with them. . . . . 3 • Partially describes how transuranic elements may be synthesised and identifies ONE safe practice that must be adopted when working with them. . . . . 2 • Partially describes how transuranic elements may be synthesised OR • Identifies ONE safe practice that must be adopted when working with them. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 19	9.2.3 H1, H3, H4, H5, H13, H16
There are numerous advantages and disadvantages to using ethanol as a fuel, such as: ADVANTAGES: • it is a renewable resource; • it is transportable; • it has a low ignition temperature and therefore is readily combustible; • it requires less oxygen than octane to completely burn, so it produces less soot and/or carbon monoxide; • it doesn't contribute to greenhouse gases because the carbon dioxide that it releases is essentially re-used in growing more plants (CO_2 neutral); • it does not produce sulfur dioxide and nitrogen oxides which are evident when other fossil fuels are combusted; • it can be mixed with other fuels (such as petrol); • it reduces our dependence on foreign fuel. DISADVANTAGES: • vast areas of land are necessary to supply enough plants to produce the quantity of ethanol required (monoculture, land degradation); • fossil-fuel energy is required to prepare and fertilise the land needed for growing the crops and for the fermentation and distillation processes; • the waste products from fermentation can be very smelly and difficult to dispose of; • it is currently still cheaper to produce fuel from fossil fuels than from ethanol; • vehicles presently on the road will require engine modifications if more than 10% ethanol is used; • it has a lower heat content than octane (46.0 kJ/g for octane and 30.6 kJ/g for ethanol) so there is a need to re-fuel more often; • it may be difficult to scale up production of ethanol to the quantities required for widespread use. CRITERIA TO BE CONSIDERED: • the cost of production, distillation etc. and the cost of altering infrastructure, designing and building new engines, etc.; • the energy content of ethanol compared with octane; • renewability and potential for long term use; • polluting emissions; • compatibility with technology.	• Demonstrates an extensive knowledge of ethanol's potential as an alternative fuel • Provides a comprehensive list describing the advantages and disadvantages of ethanol • Provides a suitable evaluation based on specific criteria ..... 5 • Demonstrates a thorough knowledge of ethanol's potential as an alternative fuel • Provides a basic list outlining advantages and disadvantages • Provides a judgement ..... 4 • Demonstrates a sound knowledge of ethanol's potential as an alternative fuel • Outlines several advantages and disadvantages of it use OR • Provides a judgement ..... 3 • Demonstrates a limited knowledge of ethanol's potential as an alternative fuel OR • Outlines several advantages and disadvantages of its use ..... 2 • Identifies some advantages and disadvantages of its use 1

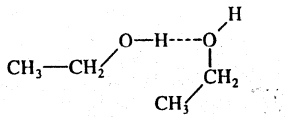
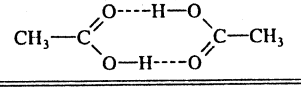
Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 19 (continued)	
EVALUATION: There are several problems associated with the use of ethanol as a fuel (as seen above), but its advantages are ultimately more important. It is sensible to attempt to overcome the issues. Fossil fuel reserves will eventually be depleted and so a renewable alternative (such as ethanol) is crucial. As costs of dwindling fossil fuels continue to rise, the relative cost of ethanol will fall. Better production processes and suitable engines need to be developed so it can become economically viable, energy efficient and widely available. Our environmental wellbeing is of vast importance and ethanol's lower levels of polluting emissions make it a desirable energy source. In order to become a market reality in the future, ethanol will have to prove to be environmentally better than current fuels. In conclusion, it seems likely that ethanol will become a workable alternative fuel in the future as long as production processes are adapted.	

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 20	
(a) The major source of NO_x is motor vehicle exhaust (combustion engine). The other significant source is the burning of fossil fuels such as coal, oil and natural gas (for purposes such as generating electricity in coal-fired power stations or during primary metal production). Increasing use and number of cars and increased burning of fossil fuels over time has lead to higher levels of NOx being released into the atmosphere.	9.3.2 H4, H13 • Gives at least one correct source of NO_x emissions AND • identifies an increase in the source which leads to greater volumes of NO_x being released. . . . . 2 • Gives at least one correct source of NO_x emissions OR • Identifies an increase in the sources of NO_x which leads to greater volumes being released 1
(b) Formation of acidic solution from NO_x occurs when the nitrogen oxides dissolve in water to form an aqueous solution of nitric acid and/or nitrous acid. The reactions occurring are: $2NO_{2(g)} + H_2O_{(l)} \rightleftharpoons HNO_{2(aq)} + HNO_{3(aq)}$ OR $4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \rightleftharpoons 4HNO_{3(aq)}$ $HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO_{3\ (aq)}^-$ (H^+ result in low pH!) Reasons for concern about production of acid rain include: • It contributes to acidification of lakes and other aquatic environments. Aquatic organisms can die as water acidity drops below pH 5. This disrupts the food web resulting in further deaths. • It can cause soil pH to drop, making it difficult for plants to absorb sufficient calcium or potassium. Growth is hindered and death of plants may result. • Changes in soil chemistry can also lead to the death of important micro-organisms and can release normally insoluble aluminium and mercury into soil water causing plants to absorb toxic levels of these and other heavy metals. • Protective waxes can be lost from leaves, causing leaf damage and thus substantial losses of trees and crops. • Buildings, statues and monuments made of carbonates (such as concrete, mortar, limestone and marble) can be gradually dissolved away: $CaCO_3(s) + 2HNO_{3(aq)} \rightarrow Ca(NO_3)_{(aq)} + CO_{2(g)} + H_2O$ • Acidic rain can also promote corrosion of metals, fade fabrics and degrade rubber. • Smog and acid rain can combine to form a "killer fog". JUDGEMENT: Damage to the natural and man-made environmental is both costly in a monetary sense as well as in cultural and ecological senses. For this reason, concerns about the effects of acid rain are warranted.	9.3.2 H4, H8, H13, H16 • Clearly explains the formation of acid solutions by dissolution of NO_x including the use of appropriate balanced equations. AND • Identifies and explains several and varied problems associated with acid rain. Demonstrates a thorough knowledge of the issues and implications and makes a clear judgement/evaluation about the value of these concerns. . . . . 4 • Outlines the formation of acid solutions by dissolution of NO_x. Includes appropriate equation. AND • Identifies several problems associated with acid rain and demonstrates a sound knowledge of the issues. A judgement/evaluation is made. . . . . 3 • Identifies need for dissolving of gases for formation of acid rain but little detail or no equations given. AND • Identifies some problems associated with acid rain. No evaluation. . . . . 2 • Identifies need for dissolving of gases for formation of acid rain but little detail and no equations given. OR • Identifies some problems with acid rain. No evaluation. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 21	9.3.4 H11, H13
<table><tr><th>Salt</th><th>pH nature</th><th>Explanation or equations</th></tr><tr><td>NH_4Cl</td><td>acidic (pH < 7)</td><td>NH_4^+ ions react with water (as follows) to form an excess of H_3O^+ ions, thus lowering pH. $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ Cl^- ion does not react with water.</td></tr><tr><td>Na_2CO_3</td><td>basic (pH > 7)</td><td>CO_3^{2-} ions react with water (as follows) to form an excess of OH^- ions, thus raising pH. $CO_3^{2-} + H_2O \rightleftharpoons HCO^{3-} + OH^-$ Na^+ ion does not react with water.</td></tr></table>	• Clearly states the correct pH nature for NH_4Cl, and Na_2CO_3 • Provides a thorough explanation for the pH nature of both salts, including correct ionic equations . . . . . 3 • States the correct pH nature of each salt and provides a sound explanation of the pH nature of all both salts, including equations OR • Provides a thorough explanation of the pH nature of one salt only, including equations . . . . . 2 • States the correct pH nature of each salt with no explanation OR • Provides limited explanation of the pH nature of the salts 1
Question 22	
(a) The observed trend is that for molecules of the same MM, alkanoic acids have a higher boiling point than the corresponding alkanol. Alkanols and alkanoic acids of the same MM exhibit dispersion forces of equivalent strength. If these were the only forces present then alkanols and alkanoic acids of the same MM would have the same boiling point. Alkanols also contain hydrogen bonding between neighbouring molecules (as seen in diagram). The $\delta+$ on H from the —OH group of one molecule is attracted to the non-bonding electrons on the O of a neighbouring molecule. Ethanol  Alkanoic acid molecules can be involved in two sites of hydrogen bonding with a neighbouring molecule. The $\delta+$ on the H from the —OH group of each molecule is hydrogen bonded to the non-bonding electrons on the O from the C=O group of the neighbouring molecule. This attraction is able to occur at two sites between each pair of molecules due to the shape of the molecules and orientation of the bonds (as can be seen in the diagram below). The additional hydrogen bond that can occur between each pair of alkanoic acid molecules results in greater energy (higher temperatures) being needed to overcome intermolecular forces during boiling (hence higher boiling point). Ethanoic acid 	9.3.5 H2, H9 • Identifies the trend. • Relates strength of intermolecular forces to boiling point. • Thoroughly describes intermolecular forces in both alkanols and alkanoic acids. • Identifies the presence of hydrogen bonding in both substances and clearly explains the reason for the alkanoic acids exhibiting more hydrogen bonds than the corresponding alkanol. • Provides a clear and complete explanation for difference in boiling point. . . . . 3 • Identifies the trend. • Relates strength of intermolecular forces to boiling point. • Identifies the presence of hydrogen bonding in both substances. • Provides a sound explanation for the difference in boiling point. . . . . 2 • Identifies the trend. • Identifies the relationship between boiling point and intermolecular forces and identifies hydrogen bonding as a strong intermolecular force. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(b)	9.3.3, 9.3.5 H3, H4
	• Names an example of an acid and an example of an ester used in food production and outlines the use of both 2
	• Names an example of both an acid and an ester OR • Outlines the use of a specific, named acid OR • Outlines the use of a specific, named ester 1

Sample acids used in processed foods	Purpose of acid
Acetic acid, citric acid, tartaric acid, malic acid, fumaric acid or lactic acid	Preservative in pickles and other processed food
Phosphoric acid	Preservative in cola drinks
Sulfur dioxide (as sulfurous acid)	Preservative in dried fruits and wine
Ascorbic acid (vitamin C)	Antioxidant to protect soft drinks, jams, condensed milk and sausage

Acids are mostly used as preservatives in processed foods. Presence of the acid destroys most microbes present (that would cause food to spoil or go off) and prevents them multiplying, so over long periods the food material is conserved.

Sample esters used in processed foods	Purpose of ester
Isoamyl acetate	Artificial banana flavouring
Octyl gallate	Antioxidant in fats and oils for frying oils, seasoning, dehydrated soups, chewing gum
Polyglycerol esters and lactic acid esters	Emulsifiers in mayonnaise, margarine, creamy sauces
Triethyl citrate	Thickener in desserts, foam stabiliser

Esters can be used as flavour additives due to their strong scent and resulting effect on taste.

Emulsifiers allow water and oils to remain mixed together in an emulsion. The ester molecules stabilise emulsions in food products, preventing them from separating.

As an antioxidant, esters prevent oxidation of food in air. They help foodstuffs keep their taste and colour and remain edible over a longer period. They stop fats turning rancid.

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 23	
(a) Bottle B: $n = \frac{m}{MM} = \frac{0.7}{44.01} = 1.59 \times 10^{-2}$ $V = n \times MV = 1.591 \times 10^{-2} \times 24.79$ $= 0.394$ L or 394 mL of CO_2 was released.	9.3.2 H10, H13 • Correctly calculates the volume of CO_2 released from Bottle *B* 1
(b) A greater amount of CO_2 gas was released in the warmer room. According to Le Chatelier, when the equilibrium system below is disturbed, the reaction will minimise the change while re-establishing equilibrium. $CO_{2(g)} + H_2O \rightleftharpoons H_2CO_{3(aq)} + \text{heat}$ At both temperatures, when the lid of the bottle is removed, the pressure of the system is reduced and the equilibrium balance is shifted to the left, releasing CO_2 gas. At the higher temperature of the warm room, there is a greater amount of heat in the system. According to Le Chatelier's Principle, the equilibrium system minimises the greater amount of heat by favouring the endothermic reverse process (to absorb some of the heat). This shifts the equilibrium further to the left than the equilibrium in the colder room. Since the reverse process releases CO_2 gas, a shift further to the left results in a greater volume of CO_2 being released at the higher temperature.	9.3.2 H8, H10, H13, H14 • Provides a thorough explanation of the effect of temperature change on the position of the equilibrium in the bottle • Relates the shift in equilibrium to Le Chatelier's principle • Correlates the relative equilibrium position to the amount of CO_2 gas released. . . . . 3 • Provides a sound explanation of the effect of temperature change on the position of the equilibrium in the bottle • Relates the shift in equilibrium to Le Chatelier's principle • Correlates the relative equilibrium position to the amount of CO_2 gas released. . . . . 2 • Correlates the amount of CO_2 gas released to the relative equilibrium position OR • Provides a limited explanation of the effect of temperature change on the position of the equilibrium in the bottle. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 24	9.3.4 H4, H11

Usefulness of advice	Drawbacks of advice
Adding $CaCO_3$ neutralises (increases the pH of) the spill liquid. It reduces the risk of corrosive reaction between skin or eyes or equipment and the acid.	The base being used to neutralise acid could be mildly hazardous in its own right. Avoiding contact of lime with eyes, airways etc. would be necessary. $NaHCO_3$ (bicarb soda) is possibly a better choice of base to use since it is slightly less hazardous than $CaCO_3$ while serving the same purpose.
Fizzing of $CaCO_3$ when added clearly indicates a reaction with the acid. When the fizzing ceases, it can be assumed that all acid is neutralised. Continue to add lime until fizzing ceases. The area can then be washed up or hosed down safely.	Heat is released during the neutralisation process. There would be a need for caution of large amounts of heat posing a burn or heat hazard during the clean-up.
The base used is not strong or soluble and thus poses minimal risk, so it provides a neutralising action with minimal risk from the base itself.	The spill could be contained from spreading first by adding sand or vermiculite to the puddle of liquid. Once this has absorbed the spill, it can then be swept up. This may be less expensive than $CaCO_3$ and larger quantities may be readily available.
The powdered sample will absorb some of the liquid of the spill, thus preventing the spread of the liquid (into drains etc.)	It's not mentioned that the area will still need to be washed down with detergent and water after the bulk of the spill is cleared away.
The advice is suitable for small or large spills of acid and for spills of strong, weak, concentrated or dilute acid.	Apart from goggles, no safety gear is specifically mentioned. Also there is no mention of the need to ventilate the area.
Lime is readily available.	

- Demonstrates a thorough knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk
- Thoroughly considers the advantages and disadvantages of using the recommended method
- Provides a detailed assessment or judgement of the problems and benefits of the method 4

- Demonstrates a sound knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk

OR

- Outlines some of the advantages and disadvantages of using the recommended method
- Provides an overall judgement of the method 3

- Demonstrates a limited knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk

OR

- Identifies an advantage and a disadvantage of using the recommended method

OR

- Provides an explanation of a problem or benefit of the method 2

- Identifies one advantage of using the method

OR

- Identifies one disadvantage of using the method 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 24 (continued)	

JUDGEMENT:

The method selected is essentially very useful and safe and gives the key information necessary to safely clear up a spill.

It minimises the risk from the acid spilt (neutralises it) and the base used in the clean-up (weak, solid form), while allowing the spill to be dealt with adequately (soaked-up liquid, fizzing as evidence of neutralisation, straightforward mop-up to finish).

However, more detail about how to go about the clean-up procedure could have been given, including working slowly from the edge of the spill inwards, adding more lime when fizzing subsides until no more fizzing occurs, and listing necessary protective gear to be worn.

Other weak base substances could be used apart from lime; however, it should be specified that the neutralising material be solid.

Question 25

(a) 'Good up high' refers to ozone in the stratosphere which acts as a filter for high-energy UVB radiation. The radiation is absorbed by the ozone, which decomposes into oxygen and a free radical.

'Bad down low' refers to ozone in the troposphere being a strong oxidant which acts as a respiratory irritant, can damage vegetation and is both an indicator of and contributor to photochemical smog.

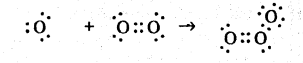
9.4.4 H4, H13

- Recognises that ozone exists in the stratosphere and the troposphere
- Ozone is a UV filter in the stratosphere
- Ozone is a pollutant in the troposphere . . 3

- States the two roles ozone may play in the atmosphere 2

- States a role that ozone plays in the atmosphere 1

(b) Ozone can be thought of as forming from molecular oxygen and an oxygen free radical.



oxygen free radical + molecular oxygen → ozone molecule

The oxygen molecule provides both of the shared electrons for the coordinate covalent bond. The two unpaired electrons on the free radical become a lone pair.

9.4.4 H6, H13

- Correctly shows the formation of ozone, including all lone pairs, and indicates the source of the bonding electrons for the coordinate bond 2

- Correctly draws molecular oxygen and an oxygen free radical. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 26	9.4.3 H8, H11, H13
To identify barium: 1. A small sample of the unknown salt should be dissolved in water in a test-tube. 2. Add 2 mL of HCl and filter. 3. Add 2 mL of H_2SO_4 to the filtrate. 4. A white precipitate should form. 5. The presence of barium needs to be confirmed with a flame test. 6. Dip a platinum wire in concentrated HCl and then heat to red-hot in a non-luminous bunsen burner flame. 7. Dip the cleaned platinum wire into the sample and heat in the flame. 8. If Ba^{2+} ions are present, an apple-green flame will be produced. A risk-minimising precaution that must be taken is the wearing of safety glasses to ensure that acid splashes cannot reach the eyes.	• Outlines an appropriate method with all steps defined that would unambiguously identify the metal ion as barium AND • Includes an appropriate risk minimisation technique . . . . . 4 • Outlines an appropriate method with most steps defined that would identify the metal ion as barium AND • Includes an appropriate risk minimisation technique . . . . . 3 • Outlines a method with most steps defined that may identify the metal ion AND • Includes an appropriate risk minimisation technique . . . . . 2 • Outlines a method with most steps defined that may identify the metal ion OR • Includes an appropriate risk minimisation technique 1
Question 27	9.4.5 H4, H8, H11
• The low DO reading could be due to eutrophication, addition of organic waste material or an elevated water temperature. • The steel factory could be using the lake's water for cooling of plant machinery and as such cause the temperature of the lake to increase. The solubility of oxygen decreases with temperature and this could explain the low DO reading. • Farmers often use fertilizers to promote the growth of their crops. If fertilizer was applied a short time before rain or heavy watering there may have been run off into Upyajumpa which included dissolved fertilizer. The fertilizer would be rich in nitrates and phosphates. These nutrients would encourage growth of aquatic plants which would lead to a high value for BOD and consequently a low DO. • Any number of people could be dumping organic waste in the lake if there was no other way to dispose of the material. The organic material would begin to decompose and would use up dissolved oxygen.	• Proposes the possible role of the factory AND the farmers. Two or more valid reasons for the low DO/high BOD readings should be included with thorough explanations to link possible sources of contamination to the quality of the water and the test results given. . . . . 4–5 • Proposes the possible role of the factory AND • the farmers by briefly outlining two possible sources of contamination, with specific reference to the DO and BOD tests. . . . . 3 • Proposes the possible role of the factory OR • the farmers by outlining one possible reason for the lake's measurements. . . . . 2 • Proposes the possible role of the factory OR • the farmers by identifying one possible reason for the lake's measurements. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 28	9.4.2 H7, H8
The temperature and pressure must be monitored in both the reaction chamber and the condenser chamber for the following reasons. The reaction chamber is where the hot mixture of nitrogen and hydrogen gases are passed over a catalyst and react to form ammonia. $N_{2(g)} + 3H_{2(g)} \overset{Fe/FeO}{\rightleftharpoons} 2NH_{3(g)} \quad \Delta H = -92\ kJ$ Temperature: the reaction is exothermic and the equilibrium (forward reaction) is favoured by low temperature. The rate of reaction is too slow at low temperatures and so a compromise temperature of around 500°C is used. The exothermic nature of the reaction means that the reaction must be carefully monitored to maintain this temperature. Pressure: the equilibrium (forward reaction) is favoured by high pressures as 4 mole of reactant gas produces only 2 mole of product gas. The pressure used is around 350 atmospheres which must be carefully monitored to maintain yield, by not dropping too low, and to ensure safety, by not going too high. The condenser chamber is where the ammonia is liquefied and collected. $NH_{3(g)} \rightleftharpoons NH_{3(l)}$ Pressure: the pressure of the gas mixture needs to be kept quite high to make it easier to liquefy the ammonia. Temperature: the gases are cooled and the liquid ammonia collected while the nitrogen and hydrogen are recycled to the reactor chamber. The pressure and temperature must be monitored to ensure that all of the ammonia is collected to ensure efficient conversion by further driving the equilibrium to replace the removed ammonia.	• Examines both the reactor and the condenser • Specifically addresses pressure and temperature • Specifically relates the need to monitor each to the equilibrium process • Addresses the extent of the reaction and the rate in the reactor • Addresses safety specifically with pressure • Addresses the temperature decrease while maintaining pressure in the condenser • Includes appropriate equations . . . . . 6 • Examines both the reactor and the condenser • Specifically addresses pressure and temperature • Relates the need to monitor each to the equilibrium process • Addresses the temperature decrease while maintaining pressure in the condenser • Addresses safety specifically with pressure • Includes an appropriate equation . . . . . 5 • Examines both the reactor and the condenser • Specifically addresses pressure and temperature • Addresses the extent of the reaction and the rate in the reactor • Addresses the temperature decrease while maintaining pressure in the condenser • Includes an appropriate equation . . . . . 4 • Mentions one of the two vessels and describes correctly the monitoring for both pressure and temperature conditions . . . . 3 • Mentions one of the two vessels and describes correctly the monitoring for one condition OR • Writes two correct equations . . . . . 2 • Mentions one of the two vessels and the need to monitor conditions for the equilibrium OR • Writes one correct equation 1

Section II

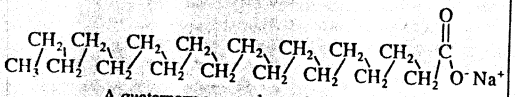
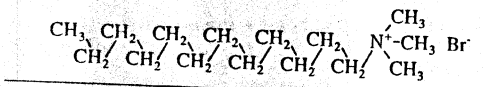
Question 29 Industrial Chemistry

		Sample answer	Syllabus content, course outcomes and marking guide
(a)	(i)	The products of the Solvay process are sodium carbonate and calcium chloride.	9.5.6 H3 • Correctly identifies the products Na_2CO_3 and $CaCl_2$ 1
	(ii)	Ammonia plays a vital role in the Solvay process, as it allows the formation of the hydrogen carbonate ion. In the process, carbon dioxide is bubbled through ammoniated brine. $CO_{2(g)} + NH_{3(aq)} + NaCl_{(aq)} + H_2O_{(l)} \rightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$ The reaction is carried out at 0°C, and the sodium hydrogen carbonate crystallises. The ammonia is vital as carbon dioxide reacts with water only to a small extent, forming carbonic acid. $CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$ The ammonia acts as a base, accepting a proton from the carbonic acid, which produces the hydrogen carbonate ion and drives the equilibrium to the right. $NH_{3(aq)} + H_2CO_{3(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + HCO_3^-{}_{(aq)}$	9.5.6 H3, H4, H13 • Recognises that CO_2 is bubbled through ammoniated brine • Explains that CO_2 reacts with brine only to a small extent • Explains that ammonia shifts the CO_2/H_2CO_3 to the right . . . . . 3 • Two of the above . . . . . 2 • One of the above 1

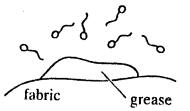
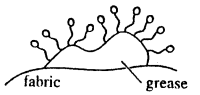
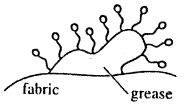
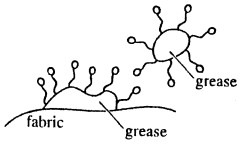
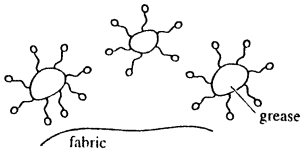
Question 29 Industrial Chemistry (Continued)

	Sample answer	Syllabus content, course outcomes and marking guide
(b)	The chlor-alkali industry uses brine to produce sodium hydroxide and chlorine gas by electrolysis. A number of factors lead to the use of brine. The possible reactants are molten sodium chloride, dilute sodium chloride solution and brine. Molten sodium chloride: Electrolysis yields sodium and chlorine according to $2NaCl_{(l)} \rightarrow 2Na_{(l)} + Cl_{2(g)}$ thus no sodium hydroxide is produced directly, but could be produced by reacting the molten sodium with water. $2Na_{(l)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + 2H_{2(g)}$ This would be dangerous and expensive, as the sodium chloride must be molten to allow electrolysis and the reaction of sodium and water is highly exothermic and constitutes a severe explosive risk. Dilute sodium chloride solution: The electrolysis of these solutions produces oxygen, hydrogen and sodium hydroxide but not chlorine. This is due to the reduction potentials of the possible reactants. At the cathode the two possible reactants are Na^+ ions and water molecules. $Na^+_{(aq)} + e^- \rightarrow Na_{(s)}$ $E° = -2.76$ V $2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$ $E° = -0.83$V The reduction of water takes less energy, and hydrogen is produced. At the anode the two possible reactants are Cl^- ions and water molecules. $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$ $E = -1.36$V $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$ $E = -1.23$V Under near-standard conditions oxygen is produced. Brine is a concentrated sodium chloride solution. Standard conditions no longer apply and while the same reactions as for dilute sodium chloride are possible at each electrode, chlorine ions are oxidised in preference to water and chlorine gas is produced at the anode. Concentration has a direct bearing on the product. The chlor-alkali industry uses brine as it is the safest and cheapest of the three possible reactants that produces the desired products.	9.5.4 H3, H8, H14 • Addresses the three possible reactants: molten NaCl, dilute NaCl solution and brine • Explains predicted products using equations for NaCl • Explains why molten NaCl is not used • Explains predicted and actual products from aqueous solutions using equations and $E°$ values • Explains the concentration dependence of the production of chlorine . . . . . 6–7 • Addresses the three possible reactants • Shows products from molten NaCl using equations but does not extend to production of NaOH • Explains predicted products using equations • Explains the concentration dependence of the production of chlorine . . . . . 4–5 • Addresses two of the possible reactants • For this pair, shows predicted products using equations • Explains the advantages of one over the other . . . . . 3 • Addresses any pair of reactants using equations . . . . . 2 • Addresses any pair of reactants 1

Question 29 Industrial Chemistry (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(c) (i) Sodium stearate, a common soap.	9.5.5 H9
$CH_3(CH_2)_{16}COO^-Na^+$	• Both structures correct 2
	• One structure correct 1
A quaternary ammonium salt, a common cationic detergent.	
$CH_3(CH_2)_{11}N^+(CH_3)_3Br^-$	
	
(ii) Soaps are used as cleaning agents for a wide range of applications, from personal bath soaps to laundry soaps. They are used to clean grease from many surfaces.	9.5.2 H4, H9
Most cationic detergents are powerful broad-spectrum biocides and form the basis of household and industrial disinfectant and sanitiser formulations.	• Lists appropriate uses for soap and cationic detergent 2
Their cationic nature causes them to adhere to negatively-charged surfaces such as glass, hair, fibre, metals and many plastics. They are not good cleaners of these materials but are used as antistatic agents, corrosion inhibitors, fabric softeners, hair conditioners, leather softeners, pigment wetting and dispersing agents and water and sewage treatment flocculants.	• Lists appropriate uses for soap or cationic detergent 1

Question 29 Industrial Chemistry (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(iii) Soap cleans materials by the dual nature of its structure. It has a hydrophobic tail, the hydrocarbon chain, and the charged carboxyl group acts as a hydrophilic head.	9.5.2 H8, H9
The soap is dissolved in water:	• Explains the dual nature of a surfactant with reference to hydrophilic and hydrophobic sections correctly
	• Explains how the surfactant attaches to the surface by one end, leaving the other end 'free'
The hydrophobic tail buries itself in the grease on the plate while the hydrophilic head remains in the water:	• Explains the formation of the emulsion or the function of the hydrocarbon tail for cationic detergent 3
	• Explains the dual nature of a surfactant • Describes in general terms the cleaning action 2
The grease begins to be pulled from the fabric with the help of some agitation of the water:	• Describes the parts of a surfactant 1
	
As more grease is exposed more soap molecules attach and the grease breaks into globules:	
	
The globules are stabilised by the soap which has its hydrophilic head forming a layer over the surface of the grease, keeping it away from other globules and dissolved in the water. This is an example of emulsification:	
	

Question 29 Industrial Chemistry (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(d) (i) $K_c = \frac{[SO_3]_e^2}{[SO_2]_e^2[O_2]_e}$ $[SO_2] = \frac{0.224}{2}M$ $[O_2] = \frac{0.136}{2}M$ $[SO_3] = \frac{0.414}{2}M$ $K_c = \frac{(0.207)^2}{(0.112)^2(0.068)}$ $K_c = 50.2$	9.5.2 H10 • Writes the equation for the equilibrium constant and calculates the correct value . . . . . 2 • Writes the equation for the equilibrium constant. 1
(ii) The production of SO_3 gas from SO_2 gas is an equilibrium process. It is at the heart of the contact process for the production of sulphuric acid. The specific conditions for this part of the process are: a temperature of about 400–450°C at close to 1 atm pressure and the use of a V_2O_5 catalyst. The reactant gases are mixed with oxygen in excess. The rate of reaction is how quickly equilibrium is established. The rate is favoured by high temperatures. The lower the temperature, the greater the yield, but the time taken to achieve equilibrium is far too great to be economical and vice versa. The temperature used is a compromise between a temperature that produces a very fast rate and one which will produce a reasonable amount of product at equilibrium. The rate is favoured by increased pressures. Increased pressure would increase both the rate and yield of this reaction. However, the reaction is carried out at close to atmospheric pressures. This is because the rate achieved by using the moderate temperature along with the catalyst is quite satisfactory as is the yield due to the use of excess oxygen and the recycling of reactant gases. It is economically less attractive to build expensive high pressure plant for the small gain in overall yield. Thus, rate and equilibrium considerations need to be carefully balanced to achieve a compromise that leads to an acceptable yield within a reasonable time.	9.5.3 H3, H8 • Lists conditions used for the contact process • Discusses rate and extent with temperature • Discusses rate and extent with pressure • Recognises that the conditions used are a compromise between the competing demands of rate and yield . . . . . 4–5 • Discusses rate and extent with temperature • Discusses rate and extent with pressure • Recognises that the conditions used are a compromise between the competing demands of rate and yield . . . . . 3 • Discusses one of temperature or pressure with regard to the rate and extent of the reaction. . . . . 2 • Mentions that compromise conditions are used 1