STUDENT NUMBER/NAME: .....

1. An unlabelled reagent bottle on a laboratory shelf contains a colourless liquid. A few drops of the liquid are shaken with bromine water in a test tube. The bromine water rapidly loses its colour. Which of the following could this substance be?

(A) Ethene
(B) Ethanol
(C) 1-hexene
(D) Methyl propanoate

2. Consider the following reaction

$$Zn_{(s)} + 2\,H^+ + 2\,MnO_{2\,(s)} \longrightarrow Zn^{2+} + Mn_2O_{3\,(s)} + H_2O_{(l)}$$

What is the oxidant in this reaction?

(A) $MnO_{2\,(s)}$
(B) $Mn_2O_{3\,(s)}$
(C) $Zn_{(s)}$
(D) H^+

3. Which of the following is true?

(A) Reduction is the loss of electrons
(B) Oxidation is the loss of electrons
(C) Oxidation is the reaction between acids and metals
(D) Oxidation is donating a proton

4. The radioisotope strontium – 90 undergoes beta decay. Which of the following is the remaining nucleus after decay?

(A) Krypton – 86
(B) Rubidium – 89
(C) Yttrium – 90
(D) Zirconium – 94

5. A spirit burner containing ethanol (molar mass 46gmol^{-1}) was used to heat a 200g sample of water, initially at 19°C, in a calorimeter. The initial mass of the spirit burner was 253.6g. After the water temperature reached 31°C, the spirit burner was extinguished and its mass was measured to be 251.9g.
From these results, which calculation gives the heat of combustion of ethanol, in kJg^{-1}?

(A) $\dfrac{200 \times 4.18 \times 103 \times 31 \times 19}{253.6 \times 251.9}$

(B) $\dfrac{200 \times 4.18 \times 10^3 \times (31 - 19)}{(253.6 - 251.9)}$

(C) $\dfrac{200 \times 4.18 \times 10^3 \times (31 - 19) \times 46}{(253.6 - 251.9)}$

(D) $\dfrac{200 \times 4.18 \times 10^3 \times (253.6 - 251.9)}{(31 - 19) \times 466}$

6. Which substance can act both as an acid and as a base, in dilute solutions?

(A) Calcium carbonate
(B) Ammonium nitrate
(C) Ethanol
(D) Water

7. The pH values of four acids and their concentrations are shown in the table below.

Acid	Conc. (mol L^{-1})	pH
P	0.01	2.0
Q	0.05	1.0
R	0.1	1.0
S	0.1	2.0

Which acid can donate more than one proton?

(A) P
(B) Q
(C) R
(D) S

8. Which group of substances below result in a lower pH when dissolved in water?

(A) Ammonia, sodium hydroxide, potassium carbonate
(B) Hydrogen chloride, ethanol, carbon monoxide
(C) Sodium oxide, magnesium oxide, calcium hydroxide
(D) Carbon dioxide, sulfur dioxide, hydrogen bromide

9. Which molecule contains a coordinate covalent bond?

(A) Water
(B) Ammonia
(C) Ozone
(D) Methane

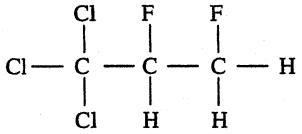
10. Two drops (0.1 mL) of 0.1 mol L^{-1} HCl is added to a small beaker of each of the following liquids.
In which case would the pH remain the same?

(A) A solution of ethanol and glucose, at equal concentrations
(B) Distilled water
(C) A solution of ethanol and ethanoic acid, at equal concentrations
(D) A solution of ammonia and ammonium chloride, at equal concentrations

11. When making the ester, ethyl propanoate, concentrated sulfuric acid is added to a mixture of ethanol and propanoic acid. One effect of the sulfuric acid is to increase the yield of the ester. Which of the following is the correct explanation for this increased yield?

(A) Sulfuric acid is a dehydrating agent and removes water as a reaction product.
(B) Sulfuric acid provides hydrogen ions which catalyse the reaction.
(C) The mixture becomes hot, which accelerates the reaction.
(D) The boiling point of the mixture increases, allowing a higher reaction temperature.

12. Identify the systematic name of the CFC molecule shown below.



(A) 1,1-dichloro-2,3-difluorobutane
(B) 1,2-difluoro-3,3,3-trichloropropane
(C) 1,1,1-trichloro-2,3-difluoropropane
(D) 1-trichloro-2,3-difluoropropane

13. Which of the following 4 carbon atom molecules has the highest boiling point?

(A) Butane
(B) Methyl propanoate
(C) Butanoic acid
(D) 2-butanol

14. Incomplete combustion of petroleum fuels is a major cause of atmospheric pollution.
Which of the following are two products of incomplete combustion?

(A) Carbon and water
(B) Carbon monoxide and hydrocarbons
(C) Ozone and carbon dioxide
(D) Nitrogen oxides and sulfur dioxide

15. Atmospheric pollution by heavy metals is monitored using dust deposit plates on which solid particles from the air settle.
An environmental scientist used atomic absorption spectroscopy to analyse the dust on one such plate. He found extremely high levels of lead.
Which of the following is the most appropriate immediate response of the scientist?

(A) Alert the local media
(B) Recommend that the nearby lead smelter be shut down
(C) Change the method of analysis, using gravimetric measurements
(D) Repeat the measurement and analyse other plates from the vicinity

Section I – continued

Part B

Total marks (60)
Attempt questions 16 – 26
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 (5 marks) **Marks**

Polyvinyl chloride (PVC) is a polymer commonly used in water pipes, electrical conduit and containers for food and other organic materials.

(a) Give the systematic name of the monomer used to produce polyvinyl chloride. **1**

.....

(b) Identify a property of polyvinyl chloride that makes it suitable for ONE of the above uses. **1**

.....

.....

.....

.....

.....

(c) The compounds used to produce polymers such as polyvinyl chloride are presently obtained from the petrochemical industry. State why alternative sources of these compounds are needed and identify TWO such sources. **3**

.....

.....

.....

.....

.....

.....

.....

.....

Question 17 (6 marks) **Marks**

Ethanol is manufactured from petrochemicals by the reaction of ethene with steam, in a high pressure vessel.

(a) Construct the equation for this reaction. **1**

.....

(b) Identify why high pressure is used for this reaction. **1**

.....

.....

(c) Outline the steps by which ethanol is produced from sugar cane. **2**

.....

.....

.....

.....

.....

(d) Define the term *renewable resource* with reference to these TWO methods of producing ethanol. **2**

.....

.....

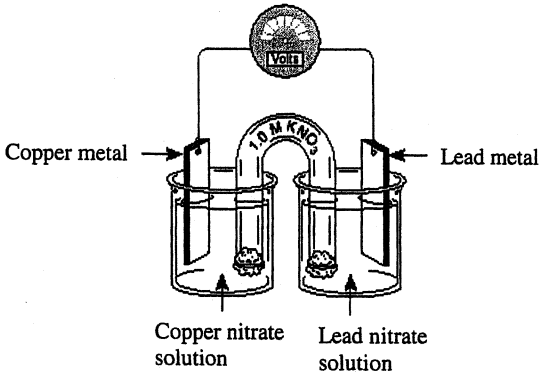
.....

.....

.....

Question 18 (8 marks) **Marks**

The diagram below shows an electrochemical cell.



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

.....

(b) Identify the anode and state its polarity. **1**

.....

(c) Predict the reading on the voltmeter, assuming standard conditions. **1**

.....

(d) Describe THREE changes that could be observed during the operation of this cell. **3**

.....

.....

.....

(e) Outline any changes in nitrate ion concentrations as the cell operates. **2**

.....

.....

.....

.....

.....

Question 19 (4 marks) **Marks**

Identify a radioisotope which is used in medicine and describe problems associated with its use **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 20 (4 marks)

Compare the terms *concentration* and *strength* as they apply to solutions of acids in water. In your answer identify ONE acid you have studied for which concentration and strength differ greatly. **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 21 (11 marks)

A crusty white deposit around the rim of an irrigation pipe is thought to consist of a mixture of sodium chloride and sodium carbonate. To test for sodium carbonate a sample of the deposit is dissolved in water. The solution is filtered and then titrated with a standard 0.118 mol L^{-1} solution of nitric acid. The measurements are recorded below:

Mass of solid sample = 1.32 g
Volume of 0.118 mol L^{-1} HNO_3 titrated = 27.3 mL
Indicator used: methyl orange (pH range 3.5-5)

(a) Describe ONE laboratory test you could perform to show the presence of sodium ions in the sample. **1**

.....

.....

(b) From the titration results calculate the mass and percentage by mass of sodium carbonate in the sample. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Identify reasons why methyl orange was selected as the indicator for this titration. **1**

.....

.....

.....

.....

Question 21 continues on the next page

Question 21 (continued)

Marks

(d) Outline a laboratory procedure you could perform to assay the proportion of sodium chloride in the sample using the titrated solution. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(e) Identify factors in the environment and irrigation farming which result in higher salt concentrations in soil. **3**

.....

.....

.....

.....

.....

.....

.....

Question 22 (7 marks) **Marks**

To analyse a white crystalline solid a student makes the following observations:

- A platinum wire dipped in the solid and held in a bunsen flame produces a bright red colour.
- The solid dissolves easily in water. The solution has a pH of approximately 9.
- In solution the compound has no visible reaction with dilute hydrochloric acid.

(a) Suggest what the white solid might be, and construct ionic equations for it dissolving in water to produce a basic solution. **3**

.....

.....

.....

(b) Describe TWO further tests you could perform to test your identification of the solid. Include relevant equations. **2**

.....

.....

.....

.....

.....

(c) Identify ONE metallic salt which produces an acidic solution in water and ONE which produces a neutral solution. **2**

Acidic:..... Neutral: .....

Question 23 (3 marks)

When 2.5L of HBr gas and 1.6L of NH_3 gas, measured at 25°C and 100kPa, are mixed, ammonium bromide is formed as a white solid.

(a) Demonstrate that this is an acid-base reaction, using Bronsted-Lowry definitions. **1**

.....

.....

(b) Calculate the mass of ammonium bromide formed in this reaction. **2**

.....

.....

.....

.....

Question 24 (4 marks)

Many fish recently died in a creek on the NSW North Coast. This was blamed by some local residents on the sewage treatment works which border the creek immediately upstream of the dead fish. Authorities stated that the sewerage plant was operating properly and that the fish deaths were a natural occurrence.

(a) Outline a procedure for sampling the creek water to detect any contamination from the sewerage plant, including safety precautions. **2**

.....

.....

.....

.....

(b) Identify TWO chemical tests you would perform on your water samples and the expected results if discharge from the sewerage plant had entered the waterway. **2**

.....

.....

.....

.....

.....

.....

Question 25 (4 marks)

Ammonium sulfate is often used as a lawn fertiliser.
A package is labelled "more than 90%" ammonium sulfate.
Describe a first-hand investigation you have performed which could be used to verify the labelling on this package. Identify safety measures taken during your investigation. **4**

.....

.....

.....

.....

.....

.....

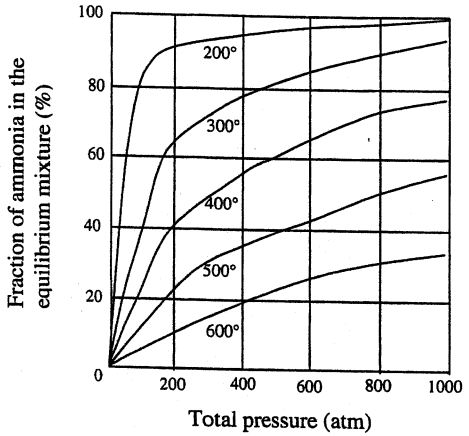
.....

.....

.....

Question 26 (4 marks) **Marks**

The graph below shows the fractions of ammonia present at equilibrium when nitrogen and hydrogen are reacted in a pressure vessel.



(a) Construct a graph showing how the yield of ammonia varies with temperature, at a total pressure of 400 atm. **2**

(b) Referring to the energy of the reaction, explain the trend shown by the graph. **1**

.....

.....

(c) Identify ONE industrial use of ammonia. **1**

.....

.....

End of Section I

Question 27 – Industrial Chemistry (25 marks) **Marks**

(a) Describe equilibrium reactions. **4**

(b) (i) Identify THREE uses of sulfuric acid in industry. **3**

(ii) Describe ONE use of sulfuric acid identified above. **2**

(c) Explain ONE electrolysis method used to produce sodium hydroxide. **3**

(d) Distinguish between anionic, cationic and non-ionic detergents. **5**

(e) (i) What is the solvay process used to produce. **1**

(ii) Identify the raw materials used in the solvay process. **3**

(f) Describe saponification **4**

End of Question 27

NSW INDEPENDENT TRIAL EXAMS
CHEMISTRY HSC TRIAL – 2006
SUGGESTED ANSWERS

PART A

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

PART B

16. (a) Chloroethene 1

(b) Non-conductor of electricity, easily moulded and rigid, impervious to water, inert to organic materials. 1

(c) Petroleum is a non-renewable resource and supplies are being rapidly used up due to heavy demand for petrochemicals for a variety of uses such as fuels, plastics, lubricants, solvents etc. This demand is increasing as the world's population increases so alternative sources of these compounds are needed in the future. In the short term, recycling of plastics can help reduce this need for alternatives. However, compounds used as fuels cannot be recycled as they are destroyed in the process. 3

17. (a) $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ 1

(b) High pressure increases the equilibrium yield of ethanol, as the forward reaction occurs with a decrease in the number of gaseous molecules. 1

(c) Sugar solution is extracted from sugar cane by crushing.
The sugar solution is fermented with yeast, producing a dilute ethanol solution. The solution is distilled to separate ethanol, which has a lower boiling temperature than water. 2

(d) Ethanol produced from ethene is using non-renewable petroleum resources, and is therefore also non-renewable. Sugar cane is a renewable crop and ethanol produced from it is a renewable substance. 2

18. (a) $Pb_{(s)} + Cu^{2+} \longrightarrow Pb^{2+} + Cu_{(s)}$ 1

(b) $Pb_{(s)}$ electrode, negative 1

(c) (+0.34) – (–0.13) = 0.47 volts 1

(d) $Pb_{(s)}$ electrode corroding, blue colour of the solution fading, build up of Cu metal on the Cu electrode 3

(e) As the cell operates, nitrate ions migrate from the Cu/Cu^{2+} half-cell to the Pb/Pb^{2+} half-cell via the salt bridge. As a result the nitrate ion concentration goes down in the copper half-cell and increases in the lead half-cell, matching the changing concentrations of Cu^{2+} and Pb^{2+} ions. 2

19. eg. Iodine-131 is used in the treatment of an overactive thyroid gland. As only the thyroid takes up iodide ion the radioisotope concentrates there where its beta radiation destroys some thyroid cells, reducing the gland's activity toward normal levels.
Associated problems include collateral damage to surrounding tissue and exposure of another person in close proximity, such as a baby held close. Also the production and transport of the isotope involves operating a nuclear reactor (or cyclotron) and must be performed with stringent safeguards against radiation exposure of personnel, including medical staff. 4

20. The molar concentration of an acid is simply the number of moles of acid dissolved per litre of solution. Concentration can be measured by titration with a standard solution of a strong base, such as sodium hydroxide, using a suitable indicator, such as phenolphthalein. 2
The strength of an acid is the extent to which the acid ionises to produce hydrogen ions in dilute solution and can be measured with a pH meter. Acetic (ethanoic) acid is one example of an acid for which the strength is much less than its concentration. 2

21. (a) A small sample of the solid will produce an intense yellow colour in a bunsen flame. 1

(b) Moles HNO_3 used = 27.3 x 0.118mmol
Moles Na_2CO_3 in sample = 27.3 x 0.118 x 0.5mmol (1:2 mole ratio) 1
Mole mass of Na_2CO_3 = 106.0g
Mass of Na_2CO_3 in sample = 27.3 x 0.118 x 0.5 x 106/1000 = 0.171g 1
Percentage of Na_2CO_3 in sample = 0.171/1.32 = 12.9% by mass. 1

(c) Na_2CO_3 is a weak diprotic base. The neutralisation point, with HNO_3 is less than 7
Methyl orange changes colour in this range and provides a sharp end-point 1

(d) (Optional: Warm the titrated solution to expel any remaining carbon dioxide.)
Add dilute silver nitrate solution, shaking the flask, until no further precipitation occurs.
Filter the silver chloride precipitate through a previously weighed filter paper.
Wash the precipitate with distilled water.
Dry the precipitate and filter paper in a warm oven.
Reweigh to obtain the mass of silver chloride.
Calculate the mass, and percentage of sodium chloride from the 1: 1 mole relation:
58.5 g NaCl(s) → 143.4 g AgCl(s) 3

(e) Salt is naturally present in soil and ancient salt deposits underlie large areas of farmland. Irrigation raises the water table bringing dissolved salt towards the surface. Evaporation leaves a residue of salt which gradually builds up. Eventually the salt reaches levels which prevent crops or pasture growth. 3

22. (a) The solid could be calcium acetate or calcium citrate (soluble calcium salt of any weak acid) 1
eg., $Ca(OAc)_{2(s)} \rightarrow Ca^{2+} + 2OAc^-$ (OAc = acetate/ethanoate) 1
$OAc^- + H_2O \Leftrightarrow HOAc + OH^-$ 1

(b) eg., calcium ion: Add dilute sulfuric acid to a solution of the unknown.
Calcium ion forms a thin white precipitate of calcium sulfate.
$Ca^{2+} + SO_4^{2-} \Leftrightarrow CaSO_{4(s)}$ 1
Acetate ion: Add a few drops of dilute HCl to a small amount of the solid. The distinctive odour of acetic (ethanoic) acid can be detected.
$Ca(OAc)_{2(s)} + 2H^+ \rightarrow Ca^{2+} + 2\,HOAc$ 1

(c) Acidic solution: eg., copper sulfate (any salt of a weak base/strong acid) 1
Neutral solution: sodium chloride (any salt of a strong acid/strong base) 1

23. (a) In this reaction HBr is a proton donor, with the proton transferred to ammonia. HBr is the acid and NH_3 is the base, using Bronsted-Lowry definitions. 1

(b) NH_3 is the limiting reagent.
Moles of NH_3 = 1.5/24.79 = 0.065 mol 1
Moles of NH_4Br = moles NH_3
Mass of NH_4Br = 0.065 x (14.0 + 4.04 + 79.9) = 6.32 g 1

24. (a) Collect water samples separately at points upstream from the sewerage works, adjacent to the works and downstream below the works. Seal and label the collection containers, with date-time and location. Avoid entering the water, wear protective gloves and eye protection. 2

(b) Any two of the test for nitrate ion, phosphate ion, biological oxygen demand and dissolved oxygen. Discharge from the plant would be indicated by elevated levels of the first three or low dissolved oxygen in the downstream water samples compared with those upstream from the plant. 2

25. Dissolve a weighed sample, of approx. 1.0g in a small volume of distilled water, in a weighed beaker.
Filter the solution and collect the filtrate.
Add 20mL of 0.5molL^{-1} barium nitrate solution. Gently boil the mixture to coagulate the precipitate of barium sulfate. Allow to cool and settle.
Decant the clear liquid. Wash the precipitate, settle and decant again. Repeat washing.

Question 25 suggested answers continues on the next page

Question 25 continued

Dry the precipitate in the beaker, cool and weigh.
Calculate the mass of ammonium sulfate from the 1:1 mole ratio, and the percentage in the sample, using the sample's mass. 3
As cadmium is a toxic heavy metal care must be taken to avoid spillage and ingestion. Gloves and eye protection should be worn and the waste deposited in a heavy metal waste container.

26 (a) Draws appropriate graph. 1
(b) The graph shows that the equilibrium fraction of ammonia falls rapidly as the temperature increases. This is because the reaction is strongly exothermic and a higher temperature drives the equilibrium towards the reactants, reducing the yield of ammonia 2
(c) Answers may include fertilisers, plastics, nitric acid, cleaners and detergents. 1

Section II Options:

Q27. Industrial Chemistry

(a) Chemical reactions may be reversible. This means that the forward reaction and reverse reaction occur simultaneously. Undisturbed in a closed system, these reactions reach equilibrium. These reactions are governed by Le Chatelier's principle, i.e. when a system in equilibrium is disturbed, the system will adjust to minimise the disturbance. In a system where equilibrium has been reached, concentrations of reactants and products will stay constant, but not necessarily equal. 4

(b) (i) Identifies three uses of H_2SO_4. May include:
Manufacture of ammonium sulfate fertiliser
Manufacture of phosphate fertiliser
Dehydrating agent
Pickling steel
Manufacture of other chemicals. e.g. detergents, dyes, synthetic rubber, film, ink etc. 3

(ii) Describes one of the uses identified in (b)(i) e.g. H_2SO_4 reacts with NH_3 to form ammonium sulfate.
Ammonium sulfate is used as a fertiliser. The reaction is as follows:
$2NH_3(g) + H_2SO_4(aq) \longrightarrow (NH_4)_2SO_4(aq)$ 2

(c) Explains an electrolysis method used to produce sodium hydroxide. May include:
Mercury process
Diaphragm process
Membrane process 3

(d) Distinguishes between anionic, cationic and non-ionic detergents. i.e:
- Anionic: negatively charged head, long hydrocarbon tail; ionic head is usually SO_4^{2-} or SO_3^-
- Cationic: positively charged head, usually ammonium compounds.
- Non-ionic: have polar terminals, form H bonds between their Oxygens in their hydrocarbon tail and water, do not make many suds, used as laundry detergents. 5

(e) (i) Identifies Sodium carbonate 1
(ii) Identifies the raw materials used in the solvay process. May include:
NaCl
Ammonia
Calcium carbonate 3

(f) Describes saponification. e.g. Conversion in basic solution of fats and oils to glycerol and salts of fatty acids. 4

Q28. Shipwrecks, Corrosion & Conservation

(a) The origins of the minerals in the world's oceans come from two sources:
-The leaching by rainwater from terrestrial environments. The rainwater penetrates the rocks and soils leaching out minerals by the process of weathering. These dissolved minerals, which are mainly calcium ions, magnesium ions, hydrogen carbonate ions and silicate ions, are carried down to the oceans and seas by creeks and rivers.
-Dissolution of salts by water passing through hydrothermal vents in mid ocean ridges. Seawater penetrates down into cracks and fissures in mid ocean ridges coming near the hot magna heating the water. This hot water is forced back out through other cracks called hydrothermal vents and as it does it dissolves minerals in the rocks. Sulfides of iron, copper and zinc form deposits that settle on the ocean floor. Chlorides and sulfates of magnesium, calcium, sodium and potassium remain in solution. 4

(b) (i) The standard electrode potentials show that relative to hydrogen
Cu will give up electrons more readily than Ag
$Cu^{2+} + 2e \longrightarrow Cu \quad +0.34$
$Ag^+ + e \longrightarrow Ag \quad +0.80$
COPPER will therefore corrode 1

(ii) $Cu_{(s)} + 2Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$
$Cu \longrightarrow Cu^{2+} + 2e^- \quad -0.34$
$2Ag^+ + 2e \longrightarrow 2Ag \quad +0.80$
$Cu + 2Ag^+ \longrightarrow 2Ag + Cu^{2+} \quad +0.46V$ 2

(iii) Cu is the anode (where oxidation occurs). The anode will decrease in mass and the colour of the Cu^{2+} solution will darken as Cu^{2+} comes from the Cu as it gives up its electrons to form Cu^{2+} in solution
Ag is the cathode (where reduction occurs). The cathode will increase in mass as Ag^+ comes out of solution picking up an electron to form Ag 2

(c) (i) Mild steel has less than 0.2% C and is soft and malleable and has a high tensile strength. It is used in car bodies, pipes, roofing and shipbuilding.
Structural steel has 0.3 – 0.6% C and is hard and malleable and has a high tensile strength. It is used in beams and girders, railways and reinforcing for buildings.
Stainless steel has 10-20% Cr and 5-20% Ni and is hard, takes on a high polish and is resistant to corrosion. It is used in kitchen sinks and appliances, cutlery, surgical and instruments. 3

(ii) Rusting occurs in the presence of oxygen and water. At the site where iron oxidises to Fe^{2+} ions this is called the anodic site. The two electrons flow through the iron metal to a site where there is an impurity. This is the cathodic site. Here oxygen is reduced to hydroxide ions in a thin film of moisture on the iron surface or in the water if the iron is submerged.
The reduction reaction is: $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$
The Fe^{2+} and OH^- ions migrate through the moisture and form insoluble $Fe(OH)_2$ ie:
$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2$.
The $Fe(OH)_2$ is oxidised to iron(III) oxide:
$4Fe(OH)_2 + O_2 \longrightarrow 2(Fe_2O_3.H_2O) + 2H_2O$.
$2(Fe_2O_3.H_2O)$ is rust. 4

Question 28 suggested answers continue on the next page