CHAPTER 9

Excel

Sample
HSC Examination Paper 1

Chemistry

General Instructions

- Reading time — 5 minutes
- Working time — 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this book (pp. 321–324)
- For questions in Section II, show all relevant working in questions involving calculations

Total marks: 100

Section I – 20 marks

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks

- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

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1 In chemical systems reactions may be reversible or irreversible. Reversible reactions are examples of dynamic equilibria. Irreversible reactions are examples of static balance or static equilibrium. Identify which response shows examples of dynamic and static equilibria.

	Dynamic equilibrium	*Static equilibrium*
(A)	Dissolution of carbon dioxide in an unopened soda water bottle	Thermal decomposition of $CaCO_3$ to form CaO and CO_2 in a flued (open) kiln
(B)	The oxidation of steel wool in a Bunsen burner flame	A saturated solution of iodine in a water–alcohol solution
(C)	The dehydration of hydrated cobalt (II) chloride crystals when heated in a test tube	A saturated solution of table sugar in water
(D)	The combustion of magnesium in a Bunsen burner flame	The combustion of magnesium in a heated, closed container

2 Identify which response correctly shows activation energy and enthalpy change information for exothermic and endothermic reactions.

	Exothermic reaction	*Endothermic reaction*
(A)	$E_A(f) < E_A(r); \Delta H > 0$	$E_A(f) > E_A(r); \Delta H < 0$
(B)	$E_A(f) > E_A(r); \Delta H > 0$	$E_A(f) < E_A(r); \Delta H < 0$
(C)	$E_A(f) < E_A(r); \Delta H < 0$	$E_A(f) > E_A(r); \Delta H > 0$
(D)	$E_A(f) > E_A(r); \Delta H > 0$	$E_A(f) < E_A(r); \Delta H > 0$

3 Select the correct statement about dynamic equilibria.

(A) If the equilibrium is endothermic an increase in temperature causes the equilibrium to shift towards the left (reactants). This shift counteracts the increase in heat content by using up some of the added heat to convert some products into reactants.

(B) If the equilibrium is endothermic a decrease in temperature causes the equilibrium to shift towards the right (products). This shift counteracts the decrease in heat content by producing some more heat to convert some reactants into products.

(C) If the equilibrium is exothermic an increase in temperature causes the equilibrium to shift towards the right (products). This shift counteracts the increase in heat content by using up some of the added heat to convert some reactants into products.

(D) If the equilibrium is exothermic an increase in temperature causes the equilibrium to shift towards the left (reactants). This shift counteracts the increase in heat content by using up some of the added heat to convert some products into reactants.

4 X_2O gas molecules are in equilibrium with their elements:

$$2X_2O(g) \rightleftharpoons 2X_2(g) + O_2(g)$$

Identify the equilibrium constant.

(A) $K_{eq} = [X_2][O_2]/[X_2O]^2$

(B) $K_{eq} = [X_2]^2[O_2]/[X_2O]^2$

(C) $K_{eq} = [X_2][O_2]/[X_2O]$

(D) $K_{eq} = [X_2]^2[O_2]/[X_2O]$

5 The solubility of ammonium chloride in water varies with temperature.

Temperature (°C)	20	40	60	80
Solubility (g/100 g water)	37	46	55	66

Identify which response correctly classifies the equilibrium in a saturated solution and the enthalpy change for the forward dissolution reaction.

	Equilibrium	*Enthalpy change*
(A)	Homogeneous	Endothermic
(B)	Homogeneous	Exothermic
(C)	Heterogeneous	Endothermic
(D)	Heterogeneous	Exothermic

6 Identify which response correctly classifies household substances as acidic, basic or neutral.

	Acidic	*Basic*	*Neutral*
(A)	Baking soda	Drain cleaner	Salt solution
(B)	Vinegar	Ammonia cleaner	Washing soda
(C)	Lemonade	Oven cleaner	Sugar solution
(D)	Lemon juice	Salt solution	Pure water

7 Identify which response correctly shows the colours of methyl orange indicator in strongly acidic and strongly alkaline solutions as well as neutral solutions.

	Strongly acidic	*Neutral*	*Strongly alkaline*
(A)	Red	Yellow	Yellow
(B)	Colourless	Colourless	Crimson
(C)	Yellow	Green	Blue
(D)	Red	Green	Blue

8 20.0 mL of 0.100 mol/L HCl is added to 180.0 mL of water to form 200.0 mL of solution. Calculate the pH and pOH of the final solution.

	pH	*pOH*
(A)	12.00	2.00
(B)	2.00	12.00
(C)	1.00	13.00
(D)	13.00	1.00

9 Identify the acidic salt in water solution.

(A) Potassium chloride

(B) Sodium acetate

(C) Sodium phosphate

(D) Ammonium nitrate

10 Identify an indicator that is appropriate to use in the titration of acetic acid solution with sodium hydroxide solution.

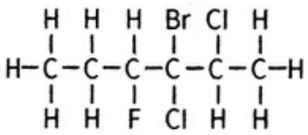
(A) Litmus

(B) Methyl orange

(C) Phenolphthalein

(D) Universal indicator

11 Use IUPAC nomenclature rules to name the following halogenated hydrocarbon:



(A) bromochlorofluorohexane

(B) 4-bromo-4-chloro-5-chloro-3-fluorohexane

(C) 3-bromo-2,3-dichloro-4-fluorohexane

(D) 4-bromo-4,5-dichloro-3-fluorohexane

12 Hydrocarbons can be extracted from petroleum via fractional distillation. Select the true statement about the hydrocarbon composition of petroleum fractions.

(A) Petrol consists of hydrocarbons with five to eight carbon atoms per molecule.

(B) The diesel oil fraction has a lower boiling point range than the kerosene fraction.

(C) The naphtha fraction is used as aviation fuel.

(D) Kerosene consists of hydrocarbons with 15 to 18 carbon atoms per molecule.

13 Hex-2-ene reacts with hydrogen chloride. Name the product(s) that will form.

(A) 2-chlorohexane

(B) 3-chlorohexane

(C) 2,3-dichlorohexane

(D) 2-chlorohexane and 3-chlorohexane

14 Pentan-2-ol is mixed with an acidified solution of potassium dichromate and heated. Identify the type of chemical reaction that will occur and the name of the product.

	Reaction classification	*Product*
(A)	Dehydration	Pentanoic acid
(B)	Oxidation	Pentan-2-one
(C)	Oxidation	Pentanoic acid
(D)	Substitution	Pentan-2-one

15 Low-density polyethylene (LDPE) has many uses based on its physical properties. Identify a common use of LDPE.

(A) Agricultural pipes

(B) DVD containers

(C) Coating in non-stick frypans

(D) Cling wrap for food packaging

16 A solution of iron (III) nitrate was tested in three separate experiments with dilute hydrochloric acid, dilute sulfuric acid and dilute sodium hydroxide solution. Identify the response that correctly shows the observations made in each experiment.

	HCl	H_2SO_4	*NaOH*
(A)	No change	Green precipitate	Orange-brown precipitate
(B)	No change	No change	Orange-brown precipitate
(C)	Green precipitate	Yellow precipitate	No change
(D)	Brown precipitate	Yellow precipitate	No change

17 Select the correct response concerning atomic absorption spectroscopy.

(A) A hollow cathode lamp made from the metal to be analysed generates specific wavelengths of light.

(B) The monochromator selects five wavelengths of light emerging from the cathode lamp.

(C) The nebuliser measures the absorbance of light by metal ions in the flame.

(D) The reference light beam passes through an atomised sample of a standard solution of the metal to be analysed.

18 The mass spectrum of methanamine (CH_3NH_2) shows a parent ion peak with an m/z value of 31. Identify the ion fragment peak that has an m/z value of 29.

(A) CH_3NH^+

(B) CH_3N^+

(C) $CHNH^+$

(D) CH_3^+

19 Select the true statement about infrared spectroscopy.

(A) The infrared spectrum of methane will show an absorption peak at 900 cm^{-1} due to the bending vibration of the C–H bond.

(B) The O–H bond in alkanols typically produce an absorption peak in the infrared spectrum in the range 2000–2500 cm^{-1}.

(C) The C=C bond in alkenes typically produce an absorption peak in the infrared spectrum in the range 1900–2200 cm^{-1}.

(D) The absorption of infrared radiation by ethane molecules will cause the C–H bonds to stretch and produce a broad peak at 2800–3100 cm^{-1}.

20 The Haber Process is used to manufacture ammonia from raw materials—air, water and natural gas. Identify why a Haber plant in Western Australia is located on the north-western coast.

(A) The ammonia produced is used to manufacture fertilisers for Western Australia.

(B) The natural gas basin is near the coast and the natural gas required for hydrogen feedstock production can be transferred by undersea pipes to the factory.

(C) This rural site minimises pollution in cities and towns in Western Australia.

(D) Strong winds along the coast allow renewable wind energy to be used to turn turbines to produce electricity to power the factory.

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21–36
Allow about 2 hours and 25 minutes for this section

Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.

Please turn over

Question 21 (6 marks) **Marks**

Iodine crystals have a low solubility in water. A saturated equilibrium is established.

(a) Write a balanced equilibrium equation for the dissolution process. **1**

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(b) Classify this equilibrium as homogeneous or heterogeneous. **1**

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(c) A small volume of saturated iodine solution containing radioactive iodine (I-131) is added to the non-radioactive saturated solution. Explain how this experiment can be used to demonstrate the dynamic nature of the dissolution equilibrium. **3**

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(d) The solubility of iodine in water is 0.034 g/100 g water. Its solubility in ethanol is 27.2 g/100 g ethanol. Explain why iodine is more soluble in ethanol than in water at 25 °C. **1**

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Question 22 (5 marks)

Photosynthesis is a chemical reaction that occurs in the chloroplasts of green plants.

(a) Water is oxidised to produce oxygen and hydrogen ions in the photosynthetic process. Write the oxidation half-equation. **1**

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(b) Carbon dioxide is reduced in the presence of hydrogen ions to form glucose and water. **1**

Write the reduction half-equation.

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(c) Write the net redox equation for photosynthesis. **1**

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Question 22 continues

Question 22 (continued) **Marks**

(d) The Gibbs free energy change for photosynthesis is +2888 kJ/mol. Determine whether photosynthesis is spontaneous or non-spontaneous under standard conditions. **1**

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(e) Explain why the chloroplasts absorb solar radiation. **1**

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Question 23 (7 marks)

Colourless hydrogen iodide gas is formed when colourless hydrogen gas and violet iodine vapour react at 250 °C. An equilibrium is established.

(a) Write a balanced equation for this reaction. **1**

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(b) The enthalpy change for this reaction is: $\Delta H = +48$ kJ/mol

Use Le Chatelier's Principle to explain how the colour of the gaseous mixture will change when the system is heated above 250 °C. **2**

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(c) Explain the effect on the equilibrium position if the volume of the vessel is halved at constant temperature. **2**

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(d) The melting point of iodine is 114 °C and its boiling point is 184 °C. Explain the effect on the equilibrium position if the reaction vessel is cooled to 110 °C. **2**

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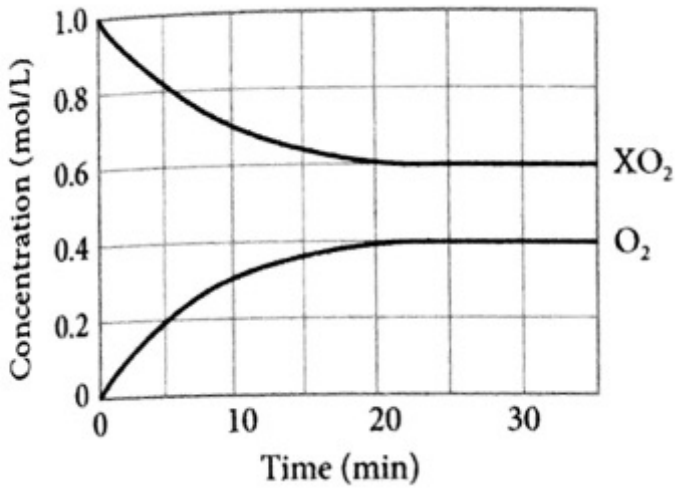
Question 24 (7 marks) **Marks**

A gaseous oxide of element *X* decomposes to form gaseous X_2 and O_2. The graph shows the concentration of two species (XO_2 and O_2) in the gaseous equilibrium at 200 °C:

$$2XO_2(g) \rightleftarrows X_2(g) + 2O_2(g)$$



(a) Use the graph and the stoichiometry of the reaction to complete the table.

Concentrations (mol/L)	XO_2	X_2	O_2
Initial			
Change			
Equilibrium			

3

(b) Write an expression for the equilibrium constant. **1**

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(c) Calculate a value for the equilibrium constant and state the position of the equilibrium. **2**

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(d) The reaction is endothermic. Explain how the position of the equilibrium changes if the temperature is increased to 300 °C. **1**

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Question 25 (6 marks)

The solubility product constant (K_{sp}) value for calcium fluoride is 3.2×10^{-11}.

(a) Write the equation for the solubility equilibrium for calcium fluoride. **1**

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(b) Write the K_{sp} expression for calcium fluoride. **1**

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Question 25 continues

Marks

(c) Calculate the solubility (in g/100 g water) of calcium fluoride at 25 °C. **4**

(1 litre water = 1000 g)

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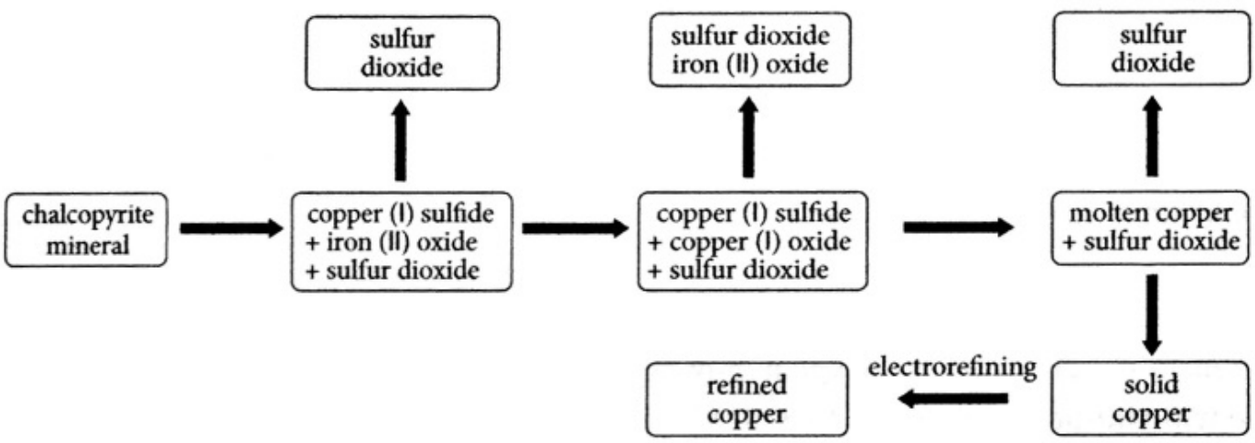
Question 26 (7 marks)

Chalcopyrite ($CuFeS_2$) is a mineral from which copper is extracted. The following flowchart shows stages in the extraction.



Use the flowchart to describe the chemical processes and industrial issues involved in the production of refined copper, using the following headings:

- Chemical reactions in the production of copper
- Suitable sites for the location of the chemical factory
- Environmental issues **7**

Question 26 continues

Question 26 (continued) **Marks**

Question 27 (2 marks)

Various indicators were used to test a sample of rainwater collected in a large industrial city.

Indicator	Litmus	Bromothymol blue	Methyl orange	Phenolphthalein	Universal indicator
Colour	Reddish-violet	Yellow	Yellow	Colourless	Orange-yellow

(a) Determine whether the rainwater is neutral, acidic or basic. **1**

(b) Determine the approximate pH of the rainwater. **1**

Question 28 (7 marks) **Marks**

25.00 mL of a standard 0.100 mol/L Na_2CO_3 solution was titrated with a solution of nitric acid of unknown concentration. The following table shows the titres.

Run	*Volume HNO_3 (mL)*
1	20.20
2	19.80
3	19.85
4	19.75

Describe the equipment and procedures used in the titration and calculate the concentration of the nitric acid solution. 7

Question 29 (7 marks)

The following data was collected for an organic compound (X).

Molar mass: 59.11 g/mol

Composition (by weight): 60.95% C; 15.35% H; 23.70% N

Melting point: –83 °C; boiling point: 49 °C

X dissolves in water and the solution turns universal indicator blue-violet.

(a) Identify the functional group present in this compound. 1

Question 29 continues

Question 29 (continued) **Marks**

(b) Calculate the empirical formula of the compound. **2**

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(c) Calculate the molecular formula of the compound. **2**

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(d) Draw and name two possible position isomers of this compound. **2**

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Question 30 (3 marks)

Identify one salt solution which, when added to each of the solutions in the set, will cause a precipitation in one of the listed solutions but not in the other. Write an ionic equation for the precipitation.

(a) Set 1: Calcium chloride and sodium chloride. **1**

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(b) Set 2: Potassium nitrate and ammonium chloride. **1**

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(c) Set 3: Sodium sulfate and sodium nitrate. **1**

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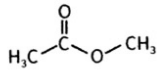
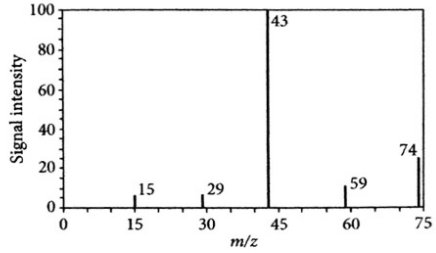
Question 31 (5 marks) **Marks**

The structural formula of methyl acetate is shown in the diagram.



The following graph shows the simplified mass spectrum of methyl acetate (methyl ethanoate). Only five peaks are shown.



Identify the formulae of the five molecular ions shown in the spectrum. 5

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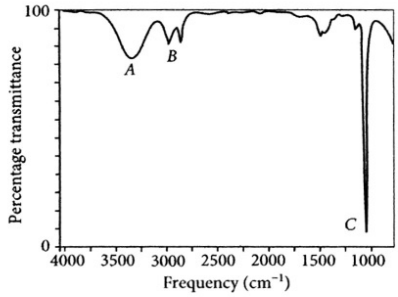
Question 32 (3 marks)

The following diagram shows the infrared spectrum of methanol.



Three bond-stretching frequency peaks are labelled *A*, *B* and *C*. Use the data table of infrared absorption frequencies to identify the three bonds. 3

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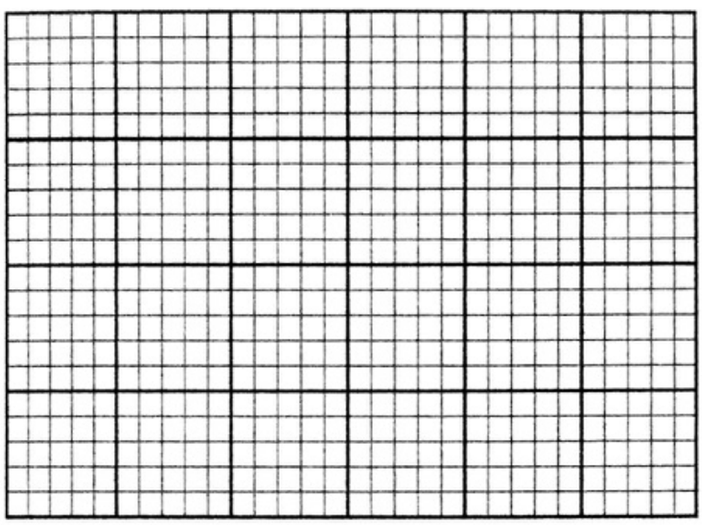
Question 33 (4 marks) **Marks**

The concentration of lead ions in a sample of polluted drain water (Z) was determined using atomic absorption spectroscopy. Five diluted standard solutions were prepared with lead ion concentration from 5 ppm to 25 ppm. Distilled water was used as a control. The absorbance of each standard and the drain-water sample were measured.

Lead ion concentration (ppm)	0	5	10	15	20	25	Z
Absorbance (A)	0	0.17	0.37	0.53	0.71	0.89	0.60

(a) Plot a calibration graph and draw the line of best fit. **3**



(b) Use the graph to determine the concentration of lead ions in the polluted water. **1**

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Question 34 (3 marks)

The molar enthalpy of neutralisation of 50.0 mL of 1.0 mol/L potassium hydroxide solution and 50.0mL of 1.0 mol/L hydrochloric acid was measured using a polystyrene foam calorimeter. The following results were collected:

Mass of solution = 103.8 g

Initial temperature = 21.3 °C

Final temperature = 27.8 °C

Calculate the molar enthalpy of neutralisation **3**
(specific heat capacity (c) = 4.18×10^3 J/kg/K).

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Question 35 (4 marks)

Marks

(a) Vinyl chloride monomers undergo addition polymerisation to form PVC.

Draw the structural formula of the monomer and a tetramer section of the polymer. **2**

(b) Beta-glucose monomers undergo condensation polymerisation to form the cellulose polymer. Draw the structural formula of the monomer and a tetramer section of the polymer. **2**

Question 36 (4 marks)

(a) Ammonia is a Lewis base because it is an electron-pair donor, and the hydrogen ion is a Lewis acid because it is an electron-pair acceptor. Draw a Lewis electron-dot diagram to show the donation of electron pairs. **2**

(b) Calcium carbonate is insoluble in water and, when universal indicator is added to the water, there is no colour change. Hydrochloric acid neutralises calcium carbonate and calcium chloride salt forms. This salt is soluble. Explain why the Arrhenius theory of acids and bases could not explain these observations. **2**

Excel

Sample HSC Examination Paper 1

Sample Answers

Section I

1 A In an unopened soda water bottle the gaseous carbon dioxide is in a dynamic equilibrium with the dissolved carbon dioxide. When calcium carbonate is thermally decomposed in an open system the carbon dioxide gas escapes to the surroundings and the reverse reaction cannot occur.

2 C In exothermic reactions the activation energy for the reverse reaction is greater than for the forward reaction. Energy is also released to the surroundings so the enthalpy change is negative. In endothermic reactions the activation energy for the reverse reaction is less than for the forward reaction. Energy is also absorbed from the surroundings so the enthalpy change is positive.

3 D In exothermic equilibria, heat is released in the forward reaction. Le Chatelier's Principle states that if the temperature is increased this will disturb the equilibrium. To counteract the change, the extra heat causes the equilibrium to reverse so heat is absorbed and more reactants form.

4 B In the equilibrium-constant expression the concentrations are raised to the powers of their moles in the balanced equation. Product concentrations are on the numerator and reactant concentrations are on the denominator.

5 C In the saturated solution, solid ammonium chloride and aquated ions exist. Thus the equilibrium is heterogeneous. Because more ammonium dissolves as the temperature increases, the forward reaction is endothermic.

6 C Soft drinks such as lemonade contain carbonic acid and fruit acids. Oven and drain cleaners contain bases such as sodium hydroxide that dissolve fats and greases. Sugar is a neutral molecule that forms a neutral solution when it is dissolved in water.

7 A

8 B The acid is diluted by a factor of 10.

HCl is a strong monoprotic acid.

$[H^+] = 0.0100$ mol/L

$c_1V_1 = c_2V_2$; $(0.100)(0.02000) = c_2(0.200)$; $c_2 = 0.0100$ mol/L

$pH = -\log_{10}[H^+] = -\log_{10}[0.0100] = 2.00$

$pOH = 14 - 2.00 = 12.0$

9 D Ammonium ions are weak Brønsted–Lowry acids. They react with water to produce hydronium ions, which makes the solution acidic:

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

Hydronium ions are strong acids whereas ammonia is a weak base.

Sodium acetate and sodium phosphate are basic salts and potassium chloride is a neutral salt.

10 C The pH at the equivalence point is >7 and phenolphthalein changes from colourless to pink in the range where the pH graph has an inflexion from pH 7 to 10. Methyl orange changes colour at pH levels less than 7. Litmus and universal indicator are used only in qualitative analysis.

11 C 3-bromo-2,3-dichloro-4-fluorohexane. Numbering the chain is from right to left to give the lowest locant set.

12 A The petrol fraction consists of hydrocarbons such as hexane, heptane and octane and their isomers.

13 D Two isomeric products will form because the chlorine atom can bond to either C-2 or C-3.

14 B Pentan-2-ol is a secondary alkanol. Acidified potassium dichromate solution oxidises the secondary alkanol to produce an alkanone.

15 D LDPE is soft and flexible due to branched polymer chains. This property is required for clingwrap.

16 B Iron (III) chloride and iron (III) sulfate are soluble and no precipitate will form. Iron (III) hydroxide is insoluble and a precipitate forms.

17 A The hot metal cathode emits specific and unique wavelengths of light. These wavelengths can be absorbed by ions of this metal when atomised in the flame. Other metal ions do not absorb these specific wavelengths.

18 B CH_3N^+. Molecular weight = 12 + 3(1) + 14 = 29 u; $z = 1$ (charge = +1); $m/z = \frac{29}{1} = 29$

19 D Alkanes have a C–H stretching frequency in the approximate range 2985–2960 cm^{-1} and a C–H bending frequency in the approximate range 1370–1480 cm^{-1}.

20 B The coastal site is near the natural gas supplies and this reduces transport costs. Economic issues are important in determining the site of a chemical factory.

Section II

Question 21 (Total 6 marks)

(a) $I_2(s) \rightleftarrows I_2(aq)$ *(1 mark)*

(b) Heterogeneous *(1 mark)*

(c) This I-123 isotope is a beta- and gamma-emitter.

There is no change in colour in the solution over time. Some hours later some iodine crystals are removed from the dish. They were washed and dried. The Geiger counter showed that the crystals had become radioactive.

Some radioactive I-123 molecules had left the saturated solution and crystallised onto the surfaces of other crystals. Because the colour intensity of the solution had not changed, the system must be in a state of dynamic equilibrium. *(3 marks)*

(d) Ethanol is much less polar than water. Iodine is a non-polar molecule and non-polar solutes have greater solubility in non-polar or low-polarity solvents due to increased dispersion interactions. Ethanol is polar with a polar end and a non-polar end. The non-polar end assists the dissolution of the non-polar iodine. *(1 mark)*

Question 22 (Total 5 marks)

(a) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ *(1 mark)*

(b) $6CO_2(g) + 24H^+(aq) + 24e^- \rightarrow C_6H_{12}O_6(s) + 6H_2O(l)$ *(1 mark)*

(c) Multiply the oxidation half-equation by six and add to the reduction half-equation. Delete like terms to obtain the net redox reaction:

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$$ *(1 mark)*

(d) The Gibbs free energy change is positive. Thus the reaction is non-spontaneous under standard conditions. *(1 mark)*

(e) Because the reaction is non-spontaneous, energy from sunlight is required to power the reaction. *(1 mark)*

Question 23 (Total 7 marks)

(a) $H_2(g) + I_2(g) \rightleftarrows 2HI(g)$ *(1 mark)*

(b) The forward reaction is endothermic.

If the system is heated the equilibrium position will shift to the right (in the endothermic direction) to counteract the change. More iodine vapour will form and so the equilibrium mixture will become more violet. *(2 marks)*

(c) Each side of the equilibrium has equal numbers of molecules.

As the volume is halved, the pressure is doubled. No change in the equilibrium position will occur because the pressure cannot be reduced by a shift in either direction. *(2 marks)*

(d) The iodine vapour will be converted to solid iodine. The concentration of iodine vapour will be much lower as solid iodine has a low vapour pressure.

The removal of most of the iodine vapour will cause the equilibrium to shift strongly to the left to counteract the change. *(2 marks)*

Question 24 (Total 7 marks)

(a) $2XO_2(g) \rightleftarrows X_2(g) + 2O_2(g)$

Concentrations (mol/L)	XO_2	X_2	O_2
Initial	1.0	0	0
Change	–0.4	+0.2	+0.4
Equilibrium	0.6	0.2	0.4

(3 marks)

(b) $K_{eq} = [X_2][O_2]^2/[XO_2]^2$ *(1 mark)*

(c) $K_{eq} = (0.2)(0.4)^2/(0.6)^2 = 0.089$

As K_{eq} is << 1, the equilibrium lies to the left. *(2 marks)*

(d) The equilibrium position shifts to the right to produce more X_2 and O_2. This shift will counteract the temperature increase, according to Le Chatelier's Principle. *(1 mark)*

Question 25 (Total 6 marks)

The solubility product constant (K_{sp}) value for calcium fluoride is 3.2×10^{-11}.

(a) $CaF_2(s) \rightleftarrows Ca^{2+}(aq) + 2F^-(aq)$ *(1 mark)*

(b) $K_{sp} = [Ca^{2+}][F^-]^2$ *(1 mark)*

(c) Let x moles of calcium fluoride dissolve in 1 litre (1000 g) of water.

Thus the concentration of calcium ions = x mol/L and the concentration of fluoride ions = $2x$ mol/L.

$[x][2x]^2 = 4x^3 = 3.2 \times 10^{-11}$

$x = 2.0 \times 10^{-4}$ mol/L

Solubility = 2.0×10^{-4} mol/L

$M(CaF_2) = 40.08 + 2(19.00) = 78.08$ g/mol

$m(CaF_2) = nM = (2.0 \times 10^{-4})(78.08) = 0.0156$ g

Solubility = 0.0156 g/L = 0.001 56 g/100 g water *(4 marks)*

Question 26 (Total 8 marks)

- *Chemical reactions in the production of copper*

The powdered chalcopyrite mineral is roasted in air and copper (I) sulfide and iron (II) oxide form. Sulfur dioxide gas is evolved.

$2CuFeS_2(s) + 4O_2(g) \rightarrow Cu_2S(l) + 2FeO(s) + 3SO_2(g)$

The copper (I) sulfide undergoes partial oxidation to form copper (I) oxide and sulfur dioxide.

$2Cu_2S(l) + 3O_2(g) \rightarrow 2Cu_2O(l) + 2SO_2(g)$

The copper (I) sulfide and copper (I) oxide undergo a redox reaction to produce molten copper and sulfur dioxide. The copper is poured into vessels to solidify.

The impure copper is used as an anode in an electrolytic cell containing copper sulfate solution. The copper is electrorefined to produce high-purity copper.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

- *Suitable sites for the location of the chemical factory*

  In regions of Australia, chalcopyrite ore bodies are located in protected areas such as national parks and Aboriginal lands.

  The chalcopyrite ore body must be large enough and have a high concentration of metal in the ore to ensure it is economically profitable.

  The electrorefining process has a high electricity usage and power must be readily available.

- *Environmental issues*

  Some chalcopyrite ore bodies may be close to ecologically sensitive areas. In such cases, mining permits may be issued only if the wilderness is protected.

  The sulfur dioxide is an acidic oxide and this will cause acid rain if released into the atmosphere. The gas is collected and used to manufacture sulfuric acid. *(7 marks)*

Question 27 (Total 2 marks)

(a) The rainwater is acidic. Universal indicator is orange-yellow in weakly acidic solution. Litmus is reddish-violet in slightly acidic solutions. *(1 mark)*

(b) The approximate pH is 5. Methyl orange is yellow above a pH of 4.4. Bromothymol blue is yellow below a pH of 6.0. Universal indicator is orange-yellow in solutions with a pH about 5. *(1 mark)*

Question 28 (Total 7 marks)

Equipment: 250 mL conical flask; 25 mL pipette; 50 mL burette; retort stand and clamp

Procedures: The flask is rinsed with water. The pipette is rinsed with water and then rinsed with the sodium carbonate solution prior to filling with the sodium carbonate solution. The burette is rinsed with water and then rinsed with the nitric acid solution prior to filling with the nitric acid solution.

Three drops of methyl orange indicator are used for a strong acid–weak base titration. The end point occurs when the indicator turns from yellow to orange-red.

Neutralisation reaction: $Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow 2NaNO_3(aq) + H_2O(l) + CO_2(g)$

Run 1 is the rough titration and that titre is not included in averaging as it is an outlier.

Average titre = 19.80 mL

Calculation:

$n(Na_2CO_3) = c.V = (0.100)(0.025\ 00) = 2.50 \times 10^{-3}$ mol

Reaction stoichiometry: $Na_2CO_3 : HNO_3 = 1 : 2$

$n(HNO_3) = 2 \times 2.50 \times 10^{-3} = 5.00 \times 10^{-3}$ mol

$$c(HNO_3) = n/V = \frac{5.00 \times 10^{-3}}{0.019\ 80} = 0.253 \text{ mol/L}$$

(7 marks)

Question 29 (Total 7 marks)

(a) Amine functional group; amines are weak bases. *(1 mark)*

(b) In 100 g of *X*: $m(C) = 60.95$ g; $m(H) = 15.35$ g; $m(N) = 23.70$ g

Calculate the number of moles of each element.

$$n(C) = \frac{60.95}{12.01} = 5.075 \text{ mol}; \; n(H) = \frac{15.35}{1.008} = 15.228 \text{ mol}; \; n(N) = \frac{23.70}{14.01} = 1.692 \text{ mol}$$

Mole ratio: C:H:N = 5.075:15.228:1.692 = 3:9:1

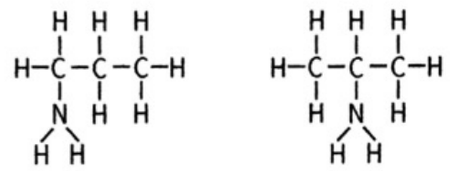
Empirical formula (EF) = C_3H_9N *(2 marks)*

(c) Empirical molar mass = 3(12.01) + 9(1.008) + 14.01 = 59.11 g/mol

$\therefore$ Molar mass = empirical molar mass

$\therefore$ MF = EF = C_3H_9N *(2 marks)*

(d)



propan-1-amine

propan-2-amine *(2 marks)*

Question 30 (Total 3 marks)

(a) Sodium carbonate; only calcium carbonate precipitates:

$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$ *(1 mark)*

(b) Silver nitrate; only silver chloride precipitates:

$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$ *(1 mark)*

(c) Barium nitrate; only barium sulfate precipitates:

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ *(1 mark)*

Question 31 (Total 5 marks)

$m/z = 74$; molecular ion = $CH_3COOCH_3^{+}$

$m/z = 59$; molecular ion = CH_3CO^{+} or $COOCH_3^{+}$

$m/z = 43$; molecular ion = $COCH_3^{+}$

$m/z = 29$; molecular ion = HCO^{+}

$m/z = 15$; molecular ion = CH_3^{+} *(5 marks)*

Question 32 (Total 3 marks)

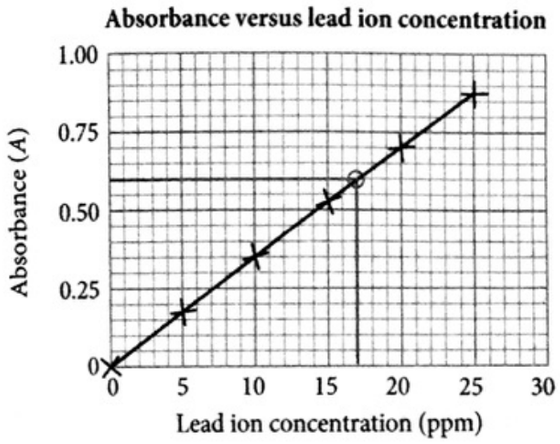
A = O–H bond (hydrogen bonded) — typical stretching frequency range = 3200–3600 cm^{-1}

B = C–H bond — typical stretching frequency range = 2850–2960 cm^{-1}

C = C–O bond — typical stretching frequency range = 1050–1150 cm^{-1} *(3 marks)*

Question 33 (Total 4 marks)

(a)



(3 marks)

(b) From the graph, $[Pb^{2+}]$ = 17 ppm *(1 mark)*

Question 34 (Total 3 marks)

$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$

$Q = mc\Delta T = (0.1038)(4.18 \times 10^3)(27.8 - 21.3) = 2820$ J

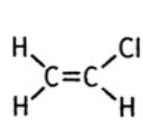
$n(HCl) = cV = (1.0)(0.050) = 0.050$ mol

$n(KOH) = cV = (1.0)(0.050) = 0.050$ mol

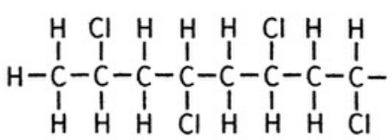
$$\Delta H = -q/n = \frac{-2820}{0.050} = -564\,00 \text{ J/mol} = -56.4 \text{ kJ/mol}$$ *(3 marks)*

Question 35 (Total 4 marks)

(a) A syndiotactic form of PVC is illustrated with chlorine atoms alternating along the chain. This form produces better packing in the crystal. The isotactic form of PVC has the chlorine atoms on the same side of the chain.

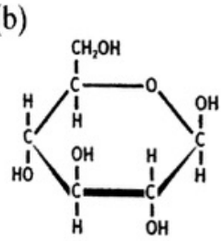


monomer

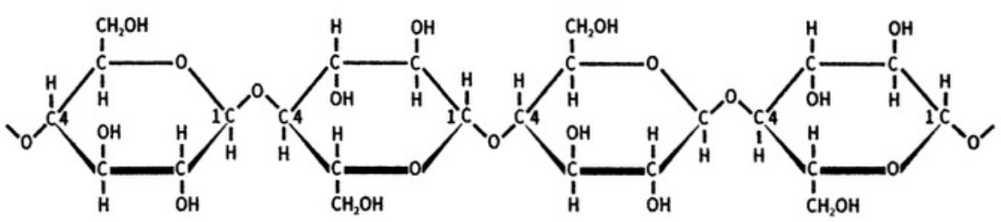


tetramer section of PVC *(2 marks)*

(b)



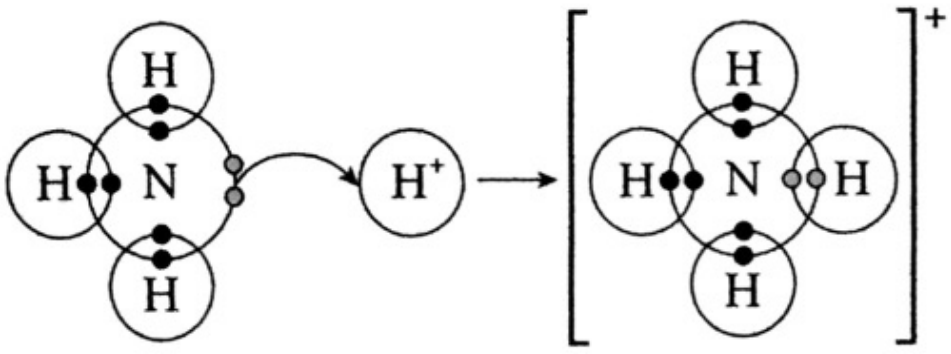
beta-glucose monomer



tetramer section of cellulose *(2 marks)*

Question 36 (Total 4 marks)

(a)



Lewis base Lewis acid *(2 marks)*

(b) Arrhenius stated that all acidic solutions are formed when acids ionise when they dissolve in the water. Hydrogen ions (H^+) are formed.

$$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$$

Arrhenius stated that a base is a substance that produces hydroxide ions (OH^-) when dissolved in water. Arrhenius stated that neutralisation reactions involved the reaction between hydrogen ions and hydroxide ions to form water.

Calcium carbonate does not contain hydroxide ions. Consequentially the Arrhenius theory cannot explain why calcium carbonate is neutralised by hydrochloric acid. *(2 marks)*