

Answer Key

Unit 1: Chemical Principles and Applications I

Module 1: Fundamentals in Chemistry

1.1.1: Atomic Structure and the Periodic Table

No.	Answers	Further explanations
1	A	
2	C	
3	B	
4	D	
5	B	<p>I: X occurs in the Lyman series. All transitions end at $n = 1$.</p> <p>II: Y occurs in the visible band of the electromagnetic spectrum. Balmer series.</p> <p>III: All energy changes associated with electronic transitions between energy levels are quantised.</p> <p>IV: X = higher energy (UV), higher frequency, shorter wavelength.</p>
6	C	
7	B	

No.	Answers	Further explanations
8	D	<ul style="list-style-type: none"> Nine electrons were removed from the atom but that does not mean that the atom had only nine electrons. The first two electrons removed (outermost electrons) required the least energy (lowest log IE). The energy required to remove those two electrons is relatively close because they are at the same principal quantum level. A significantly larger quantity of energy was required to remove the third electron because it came from a lower quantum level. The two electrons removed before a change in quantum level were in an s orbital.

1.1.2 Forces of Attraction

No.	Answers	Further explanations
1	D	<p>I Not ionic solid. A low melting point, non-polar material, which dissolves in a non-polar solvent.</p> <p>II Not ionic solid. Sublimation indicates weak intermolecular forces of attraction.</p> <p>III Identity uncertain. Properties could be for an insoluble ionic solid or a giant covalent solid.</p> <p>IV Clearly Ionic solid. Solubility in water suggests the presence of ions or highly polar particles. High melting and boiling points indicates strong forces of attraction.</p>
2	B	
3	A	
4	C	
5	C	
6	B	
7	D	

No.	Answers	Further explanations
8	A	The naphthalene molecule is made up of carbon and hydrogen atoms held together by strong sigma and pi covalent bonds. The molecule is non-polar because the difference in electronegativity between carbon and hydrogen is low. The forces of attraction between the particles are van der Waals dispersion forces that arise when short-lived instantaneous dipoles form intermittently.
9	B	
10	C	

1.1.3: The Mole Concept

No.	Answers	Further explanations
1	A	
2	C	<p>The mole ratios are:</p> <p>I $\text{Cr}_2\text{O}_7^{2-} : \text{I}_2$</p> <p> 1 : 3</p> <p>II $\text{I}_2 : \text{S}_2\text{O}_3^{2-}$</p> <p> 1 : 2</p> <p>III $\text{Cr}_2\text{O}_7^{2-} : \text{S}_2\text{O}_3^{2-}$</p> <p> 1 : 6</p>
3	B	
4	D	
5	B	

No.	Answers	Further explanations
6	D	<p>The measurement for the sulfuric acid is not included in the calculations.</p> <ul style="list-style-type: none"> Step 1: Calculate the number of moles of MnO_4^- present in 19.70 cm^3 $0.0197 \text{ dm}^3 \times 0.019 \text{ mol dm}^{-3} = 0.00037 \text{ mol}$ Step 2: Use the balanced ionic equation to determine the mole ratio $\begin{array}{ccc} \text{MnO}_4^- & : & \text{Fe}^{2+} \\ 1 & : & 5 \end{array}$ Step 3: Use the mole ratio to calculate the number of moles of Fe^{2+} in 25 cm^3 $0.00037 \text{ mol} \times 5 = 0.0019 \text{ mol}$ Step 4: Calculate the molar concentration of Fe^{2+} $0.0019 \text{ mol} \div 0.025 \text{ dm}^3 = 0.076 \text{ mol dm}^{-3}$ Step 5: Convert molar concentration to mass concentration $0.076 \text{ mol dm}^{-3} \times 55.85 \text{ g mol}^{-1} = 4.2 \text{ g dm}^{-3}$

1.1.4: Redox Reactions

No.	Answers	Further explanations
1	B	
2	D	$2\text{MnO}_4^- + 5\text{H}_2\text{O}_2 + 6\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{O}_2$ <ul style="list-style-type: none"> Separate the oxidation and reduction portions of the equations and put in the electrons to account for the increase or decrease oxidation numbers: $\text{Reduction: } 2\text{MnO}_4^- + 6\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O}$ $\text{Oxidation: } 5\text{H}_2\text{O}_2 \rightarrow 5\text{O}_2 + 10\text{e}^-$ Balance the hydrogen ions in the two half equations: $\text{Reduction: } 2\text{MnO}_4^- + 16\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O}$ $\text{Oxidation: } 5\text{H}_2\text{O}_2 \rightarrow 5\text{O}_2 + 10\text{e}^- + 10\text{H}^+$

No.	Answers	Further explanations
3	C	
4	A	

1.1.5: Kinetic Theory

No.	Answers	Further explanations
1	C	
2	A	<p>The value $pV/RT = \text{number of moles}$ is constant for an ideal gas.</p> <p>As temperature increases the values for pV/RT against p approach the ideal gas line.</p> <p>As pressure decreases the values for pV/RT against p approach the value $p = 0$.</p> <p>Real gases approach ideal behaviour at high temperatures and low pressure.</p>
3	D	<p>The ideal gas equation is applicable to this question:</p> $pV = \frac{mRT}{TM}$ $M = \frac{mRt}{pV} = \frac{0.445 \text{ g} \times 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \times 298 \text{ K}}{1.01 \times 10^5 \text{ Pa} \times 2.5 \times 10^{-4} \text{ m}^3}$ $= 44 \text{ g mol}^{-1}$ <p>Remember:</p> <p>$\text{J} = \text{Nm}$</p> <p>$\text{Pa} = \text{Nm}^{-2}$</p>
4	A	
5	B	
6	C	

1.1.6: Energetics

No.	Answers	Further explanations
1	D	
2	B	
3	B	
4	A	Standard enthalpy change of neutralisation is the enthalpy change when an acid and a base react to form one mole of water. The value varies between 55 and 58 kJ mol ⁻¹ for reactions between strong acids and strong bases.
5	C	The ionic radius of the chloride anion is the same for the three compounds. The ionic radii of the cations increase from Na to K to Rb. Therefore, the interionic distances increase.
6	A	
7	C	
8	B	
9	D	
10	C	

Module 2: Kinetics and Equilibria

1.2.1: Rates of Reactions

No.	Answers	Further explanations
1	A	
2	C	<p>Experiments 1 and 2: concentrations of X and Z are constant. The concentration of Y doubles but the rate remains constant. The reaction is zero order with respect to the concentration of Y.</p> <p>Experiments 4 and 5: concentrations of X and Y are constant. The concentration of Z quadruples and the rate quadruples. The reaction is first order with respect to the concentration of Z. Comparison with experiments 1 and 3 also confirm this.</p> <p>Experiments 1 and 5: concentrations of Y and Z are constant. The concentration of X changes by 0.75 and the rate changes by 0.75. The reaction is first order with respect to the concentration of X.</p> <p>Rate = $k [X]^1 [Y]^0 [Z]^1$ or rate = $k [X]^1 [Z]^1$ or rate = $k [X] [Z]$</p>
3	B	
4	D	
5	D	<p>Using experiment 1</p> $k = \frac{\text{rate}}{[A] [B]^2} = \frac{2 \text{ mol dm}^{-3} \text{ s}^{-1}}{0.25 \text{ mol dm}^{-3} \times (1.4 \text{ mol dm}^{-3})^2} = 4.1 \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$
6	A	
7	B	
8	C	

1.2.2: Principles of Chemical Equilibria

No.	Answers	Further explanations
1	B	
2	D	
3	B	
4	C	Greater changes in concentrations occur to establish equilibrium when starting with SO ₃ than when starting with SO ₂ or O ₂ .
5	A	The reaction is endothermic. If the equilibrium is disturbed by an increase in temperature then the equilibrium position shifts to the right in order to absorb the added heat and re-establish equilibrium.
6	C	

1.2.3: Acid and Base Equilibria

No.	Answers	Further explanations
1	C	H ₂ PO _{4(aq)} ⁻ can donate a proton and form HPO _{4(aq)} ²⁻ or accept a proton and form H ₃ PO _{4(aq)} .
2	A	pH is the negative log of [H ⁺], which in this instance is 1.5 × 10 ⁻³ mol dm ⁻³ pH = -log(1.5 × 10 ⁻³) = 2.8
3	D	$K_a = \frac{[H^+][HCOO^-]}{[HCOOH]}$ <p>pH of HCOOH is given as 5.26</p> $pH = -\log[H^+]$ $-\log[H^+] = 5.26$ $[H^+] = 5.495 \times 10^{-6}$ <p>Now the concentration of H⁺ and HCOO⁻ will be the same, therefore the equation for K_a becomes:</p> $K_a = \frac{[H^+]^2}{[HCOOH]}$ <p>Substituting the values we know into the equation gives:</p> $K_a = \frac{(5.495 \times 10^{-6})^2}{1} = 3.02 \times 10^{-11}$

No.	Answers	Further explanations
4	B	
5	C	
6	A	
7	B	
8	A	

1.2.4: Buffers and pH

No.	Answers	Further explanations
1	C	
2	B	
3	A	<p>To calculate the pH of an acidic buffer:</p> $\text{pH} = \text{pK}_a + \log \frac{[\text{conjugate base}]}{[\text{acid}]}$ $= 4.74 + \log \left(\frac{0.5}{0.1} \right)$ $= 4.74 + 0.699$ $= 5.44$
4	D	
5	B	
6	C	

1.2.5: Solubility Product

No.	Answers	Further explanations
1	B	
2	D	

No.	Answers	Further explanations
3	C	$K_{sp} = [\text{Ag}^+]^2 [\text{CrO}_4^{2-}]$ <p>Let $[\text{AgCrO}_4] = x$, $[\text{Ag}^+] = 2x$, $[\text{CrO}_4^{2-}] = x$</p> $K_{sp} = (2x)^2 (x)$ $= 4x^3$ $x = \sqrt[3]{\frac{K_{sp}}{4}}$ $= \sqrt[3]{\frac{1.20 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9}}{4}}$ $= 6.69 \times 10^{-5} \text{ mol dm}^{-3} \text{ silver chromate}$ <p>Mass concentration = $6.69 \times 10^{-5} \text{ mol dm}^{-3} \times 332 \text{ g mol}^{-1}$</p> $= 2.22 \times 10^{-2} \text{ g dm}^{-3}$
4	C	

1.2.6: Redox Equilibria

No.	Answers	Further explanations
1	B	
2	A	
3	C	
4	D	
5	D	
6	A	

No.	Answers	Further explanations
7	D	$\text{Zn}_{(s)} \mid \text{Zn}^{2+}_{(aq)} \parallel \text{Cu}^{2+}_{(aq)} \mid \text{Cu}_{(s)} \quad E^{\theta}_{\text{cell}} = +1.10 \text{ V}$ <p>Standard electrode potentials and standard cell potentials are measured under standard conditions.</p> <p>During the operation of the Daniell cell, electrons flow from the zinc anode to the copper cathode.</p> <p>If the concentration of aqueous zinc is greater than 1 mol dm^{-3} at 298 K then the ratio of $[\text{Zn}^{2+}]/[\text{Cu}^{2+}]$ is greater than 1 and the cell potential is less than the standard cell potential. In the Daniell cell the value becomes less positive.</p>
8	B	<p>I $\text{Cl}_2 + 2e^- \rightleftharpoons 2\text{Cl}^- \quad E^{\theta} = +1.36 \text{ V}$</p> <p>II $\text{MnO}_4^-_{(aq)} + 8\text{H}^+_{(aq)} + 5e^- \rightleftharpoons \text{Mn}^{2+}_{(aq)} + 4\text{H}_2\text{O}_{(l)} \quad E^{\theta} = +1.52 \text{ V}$</p> <p>III $\text{S}_2\text{O}_8^{2-}_{(aq)} + 2e^- \rightleftharpoons 2\text{SO}_4^{2-}_{(aq)} \quad E^{\theta} = +2.01 \text{ V}$</p> <p>Under acidic conditions, in a reaction between equations I and II, the chloride ions would be oxidised to chlorine gas because the manganate(VII) system has the more positive standard electrode potential.</p> <p>In a reaction between equations II and III, sulfate is not oxidised because the persulfate system has the more positive standard electrode potential.</p>

Module 3: Chemistry of the Elements

1.3.1: Period Sodium to Argon

No.	Answers	Further explanations
1	B	Across Period 3 from Na to Al, the electrons in each atom are held more tightly by the nucleus. This causes a decrease in the atomic radius, and so more atoms can be squeezed into a given volume. Hence the density of the metals increases across Period 3. The density reaches a maximum at Al.
2	D	
3	A	

No.	Answers	Further explanations
4	D	
5	D	
6	C	Aluminium oxide is insoluble in water therefore it does not react with water to form aluminium hydroxide.
7	B	

1.3.2: Group II Elements

No.	Answers	Further explanations
1	D	
2	A	
3	A	
4	C	<p>Solubility of Group II sulfates decrease down the group because the values $\Delta H_{\text{solution}} = \Delta H_{\text{lattice dissociation}} - \Delta H_{\text{hydration}}$ becomes less exothermic down the group.</p> <p>$\Delta H_{\text{lattice dissociation}}$ and $\Delta H_{\text{hydration}}$ decrease down the group.</p> <p>If $\Delta H_{\text{lattice dissociation}} < \Delta H_{\text{hydration}}$, the sulfate dissolves.</p> <p>If $\Delta H_{\text{lattice dissociation}} > \Delta H_{\text{hydration}}$, the sulfate does not dissolve.</p>
5	D	
6	C	

1.3.3: Group IV Elements

No.	Answers	Further explanations
1	B	<p>Carbon as diamond does not conduct electricity because the electrons are all tightly bound and not free to move.</p> <p>Silicon, germanium and grey tin are semiconductors.</p> <p>White tin and lead are normal metallic conductors of electricity.</p>

No.	Answers	Further explanations
2	C	
3	A	
4	D	For the compounds CO_2 , SiO_2 , GeO_2 , SnO_2 and PbO_2 thermal stability decreases down the group. Lead(IV) oxide, $\text{PbO}_{2(s)}$, when heated decomposes to $\text{PbO}_{(s)}$ and $\text{O}_{2(g)}$.
5	C	
6	D	
7	A	
8	B	

1.3.4: Group VII Elements

No.	Answers	Further explanations
1	B	
2	A	
3	C	
4	D	Down Group VII, the hydrogen halides become less stable because bond strengths decrease down the group. In addition: <ul style="list-style-type: none"> • Enthalpy changes of bond dissociation DECREASE down the group. • Acid strengths INCREASE down the group. • Bond lengths INCREASE down the group.
5	C	

No.	Answers	Further explanations
6	A	<p>Sulphuric is not a strong enough oxidising agent to oxidise chloride to chlorine:</p> $\text{NaCl}_{(s)} + \text{H}_2\text{SO}_{4(aq \text{ conc})} (\text{heat}) \rightarrow \text{HCl}_{(g)} + \text{NaHSO}_{4(aq)}$ <p>Reaction of sodium fluoride proceeds like sodium chloride.</p> <p>Iodide and bromide are oxidised by concentrated sulfuric acid to molecular iodine and bromine.</p>
7	B	

1.3.5: First Row Transition Elements

No.	Answers	Further explanations
1	C	
2	A	
3	D	
4	B	
5	D	
6	B	
7	A	Stability constant is the equilibrium constant that describes the strength of the force of attraction between a central atom and the ligands surrounding it.
8	C	The stability constant for a carbon monoxide/haemoglobin complex is higher than the stability constant for an oxygen/haemoglobin complex.

1.3.6: Identification of Cations and Anions

No.	Answers	Further explanations
1	C	
2	A	
3	D	
4	B	<p>In the presence of hydrochloric acid, the barium sulfate(IV) precipitate does not form. Instead the sulfate(IV) anion reacts with hydrogen ions to produce sulfur dioxide and water:</p> $\text{SO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
5	A	<p>Ammonium cation reacts with a base to produce ammonia gas and water:</p> $\text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l})$ <p>The reactions may also be in the solid phase.</p>
6	C	
7	A	

Answer Key

Unit 2: Chemical Principles and Applications II

Module 1: The Chemistry of Carbon Compounds

2.1.1: Structure and Formulae

No.	Answers	Further explanations
1	C	
2	B	
3	A	
4	A	
5	D	
6	C	<p>Steps to name compound R:</p> <p>(i) The longest carbon chain has six carbons</p> <p>(ii) The possible locations of the substituents are:</p> <p>a. 2-chloro, 3-bromo, 4-methyl</p> <p>b. 3-methyl, 4-bromo, 5-chloro</p> <p>(iii) Select the lowest location numbers for the substituents</p> <p>(iv) Place the substituents in alphabetical order: 3-bromo-2-chloro-4-methylhexane</p>

No.	Answers	Further explanations
7	B	
8	C	
9	B	
10	A	Isomer 1: $\text{CH}_2=\text{CHCH}_2\text{CH}_3$ Isomer 2: $\text{cis-CH}_3\text{CH}=\text{CHCH}_3$ Isomer 3: $\text{trans-CH}_3\text{CH}=\text{CHCH}_3$

2.1.2: Functional Group Analysis, Reactions and Mechanisms

No.	Answers	Further explanations
1	D	
2	B	
3	A	<p>Initiation – stage IV. Homolytic fission of the chlorine molecule to form highly reactive chlorine atoms or free radicals.</p> <p>Propagation – stages II then III. First, homolytic fission of a carbon to hydrogen bond to create an unpaired electron on the alkane radical. Second, the alkane free radical induces homolytic fission of another chlorine molecule. The chlorine atom lost in stage II is regenerated in stage III.</p> <p>Termination – stage I. Two free radicals join and are lost to the chain reaction.</p>
4	C	

No.	Answers	Further explanations
5	C	<p>Hot acidified potassium manganate(VII) is a very aggressive oxidising agent which reacts with alkenes in the following sequence:</p> <ol style="list-style-type: none"> 1. Oxidises carbons in the double bond to dialcohol 2. Cleaves the bond between the two alcoholic carbons 3. Oxidises the alcoholic groups further to ketone (2° alcohol), aldehyde (1° alcohol) 4. Oxidises aldehyde to carboxylic acid 5. Oxidises methanoic acid to carbon dioxide <p>The formation of carbon dioxide indicated that the double bond of the alkene was between carbons 1 and 2 of a chain.</p>
6	D	
7	B	
8	C	
9	A	<p>Liquid oils contain one or more carbon to carbon double bonds generally in the <i>cis</i> arrangement. During the hydrogenation process hydrogen is added across one or more of the double bonds. Some of the double bonds that are not hydrogenated may change into the <i>trans</i> arrangement.</p> <p>Trans fats in the diet lead to an increase of LDL or bad cholesterol.</p>
10	C	
11	A	
12	D	<p>An alcohol which is resistant to oxidation by strong oxidising agents is most likely a tertiary alcohol.</p> <p>In a tertiary alcohol the hydroxyl group is attached to a carbon which is attached to three other carbons.</p>
13	C	
14	B	

No.	Answers	Further explanations
15	A	2-bromo-2-methyl butane is a tertiary halogenoalkane. The electronegative bromine ionises and leave a carbocation which is stabilised by the electron donating alkyl groups. The carbocation reacts with the hydroxide anion to form an alcohol.
16	B	
17	A	
18	D	
19	A	
20	B	
21	A	
22	D	
23	C	
24	D	
25	B	
26	C	
27	B	
28	A	
29	B	The nitration agent is NO_2^+ Concentrated nitric acid is protonated by concentrated sulfuric acid, which is the stronger oxidising agent: $\text{HNO}_3 + \text{H}^+ \rightarrow [\text{H}_2\text{NO}_3]^+ \rightarrow \text{NO}_2^+ + \text{H}_2\text{O}$
30	C	
31	D	

2.1.3: Acidic and Basic Character of Organic Compounds

No.	Answers	Further explanations
1	C	
2	B	
3	A	The carbon attached to the carboxylic group is called the alpha carbon. Two electronegative fluorine atoms on the alpha carbon withdraw electrons strongly from the carboxylic group, which ionises more easily.
4	D	
5	A	
6	A	

2.1.4: Macromolecules

No.	Answers	Further explanations
1	B	
2	D	
3	C	
4	A	The structure of a protein polymer may be identified by the sequence of the amine groups and the carboxylic groups. The correct sequence can be identified by one amine group followed by an R group and one carboxylic groups, that is, resulting from condensation of alpha amino acids.
5	B	Acyl chlorides are more reactive than carboxylic acids and are sometimes used instead. For polymerisation processes, diacyl chlorides are used.
6	D	
7	A	

Module 2: Analytical Methods and Separation Techniques

2.2.1: Uncertainty in Measurements

No.	Answers	Further explanations																																		
1	B																																			
2	D																																			
3	C																																			
4	A	<p>Let mass of each flask = x and the mean = \bar{x}</p> <table border="1"> <thead> <tr> <th>Flask #</th> <th>$x, \text{ g}$</th> <th>$x - \bar{x}, \text{ g}$</th> <th>$(x - \bar{x})^2, \text{ g}^2$</th> <th>$\Sigma(x - \bar{x})^2, \text{ g}^2$</th> <th>$\Sigma(x - \bar{x})^2 \div 5, \text{ g}^2$</th> <th>$\sqrt{\Sigma(x - \bar{x})^2 \div 5}, \text{ g}$</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>10.10</td> <td>0.10</td> <td>0.010</td> <td rowspan="6">0.232</td> <td rowspan="6">0.046</td> <td rowspan="6">0.214</td> </tr> <tr> <td>2</td> <td>10.55</td> <td>0.35</td> <td>0.123</td> </tr> <tr> <td>3</td> <td>10.00</td> <td>0.20</td> <td>0.040</td> </tr> <tr> <td>4</td> <td>10.01</td> <td>0.19</td> <td>0.036</td> </tr> <tr> <td>5</td> <td>10.20</td> <td>0.00</td> <td>0</td> </tr> <tr> <td>6</td> <td>10.35</td> <td>0.15</td> <td>0.023</td> </tr> </tbody> </table>	Flask #	$x, \text{ g}$	$x - \bar{x}, \text{ g}$	$(x - \bar{x})^2, \text{ g}^2$	$\Sigma(x - \bar{x})^2, \text{ g}^2$	$\Sigma(x - \bar{x})^2 \div 5, \text{ g}^2$	$\sqrt{\Sigma(x - \bar{x})^2 \div 5}, \text{ g}$	1	10.10	0.10	0.010	0.232	0.046	0.214	2	10.55	0.35	0.123	3	10.00	0.20	0.040	4	10.01	0.19	0.036	5	10.20	0.00	0	6	10.35	0.15	0.023
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6	10.35	0.15	0.023																																	
5	C	<p>Mean +1 standard deviation = $10.20 \text{ g} + 0.214 \text{ g} = 10.414 \text{ g}$ Mean +2 standard deviation = $10.20 \text{ g} + 0.428 \text{ g} = 10.628 \text{ g}$ Mean +3 standard deviation = $10.20 \text{ g} + 0.642 \text{ g} = 10.842 \text{ g}$ Mean -1 standard deviation = $10.20 \text{ g} - 0.214 \text{ g} = 9.986 \text{ g}$ Mean -2 standard deviation = $10.20 \text{ g} - 0.428 \text{ g} = 9.772 \text{ g}$ Mean -3 standard deviation = $10.20 \text{ g} - 0.642 \text{ g} = 9.558 \text{ g}$</p> <p>The variation in the masses of the water contained by the six flasks is random (low variability) because all measured values are within ± 2 standard deviations of the mean. However, the measured values are biased because they are all equal to or greater than 10.</p>																																		
6	B																																			

2.2.2: Titrimetric (Volumetric) Methods of Analysis

No.	Answers	Further explanations
1	A	
2	C	
3	B	The silver and glass electrodes indicates that this is a potentiometric titration apparatus. The silver electrode detects changes in the concentration of silver ions in the titrating container. The measuring device measures the potential difference in volts or millivolts between the silver electrode and the reference glass electrode.
4	A	
5	D	
6	B	<p>NaOH 1000 cm^3 contains 1 mol 250 cm^3 contains 0.25 moles 25 cm^3 contains 0.025 moles</p> <p>HCl 1000 cm^3 contains 1 mol 24.15 cm^3 contains 0.02415 mol</p> <p>Excess moles NaOH from $25 \text{ cm}^3 = 0.02415 \text{ mol}$</p> <p>NaOH reacted from $25 \text{ cm}^3 = 0.025 - 0.02415 \text{ mol} = 0.00085 \text{ mol}$</p> <p>NaOH reacted from $250 \text{ cm}^3 = 0.0085 \text{ mol}$</p> <p>2-ethanoylhydroxybenzoic acid Moles = $0.0085 \div 2 = 0.00425 \text{ mol}$ Mass = $0.00425 \text{ mol} \times 180.16 \text{ g mol}^{-1} = 0.76568 \text{ g}$ % = $0.76546 \text{ g} \div 1.5 \text{ g} \times 100 = 51\%$</p>
7	C	
8	A	

2.2.3: Gravimetric Methods of Analysis

No.	Answers	Further explanations
1	C	
2	B	
3	D	<p>NaCl 1 dm^3 contains 1 mol 0.01 dm^3 contains 0.01 mol</p> <p>$\text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{AgCl}_{(\text{s})}$</p> <p>Mole ratio: $\text{Cl}^- : \text{Ag}^+ : \text{AgCl}$ $1 : 1 : 1$</p> <p>AgCl, $143.35 \text{ g mol}^{-1}$ Mass expected = $0.01 \text{ mol} \times 143.35 \text{ g mol}^{-1} = 1.43 \text{ g}$</p>
4	A	

2.2.4: Spectroscopic Methods of Analysis

No.	Answers	Further explanations
1	C	<p>$\Delta E = h\nu$ $= 6.63 \times 10^{-34} \text{ J s} \times 10^{13} \text{ s}^{-1}$ $= 6.63 \times 10^{-21} \text{ J}$</p>
2	D	
3	B	

2.2.5: Ultraviolet–Visible (UV/VIS) Spectroscopy

No.	Answers	Further explanations
1	D	
2	A	<p>The pair of electrons in single bonds like C–H do not absorb in the ultraviolet–visible band. The electrons in double, triple bonds, conjugated double bonds and lone pairs are more loosely held and so absorb strongly in the UV-VIS band of the electromagnetic spectrum.</p>
3	B	

No.	Answers	Further explanations
4	C	
5	A	$A = \epsilon cl$ $\epsilon = A \div cl$ $= 0.015 \div 5.0 \times 10^{-3} \text{ mol dm}^{-3} \times 1 \text{ cm}$ $= 3 \text{ mol}^{-1} \text{ dm}^3 \text{ cm}^{-1}$

2.2.6: Infrared Spectroscopy

No.	Answers	Further explanations
1	B	
2	D	
3	C	<p>Primary amines show N–H stretch between 3500 and 3300 cm^{-1}. Secondary amines show N–H stretch between 3450 and 3300 cm^{-1}. Tertiary amines do not have N–H bonds and do not show peaks in these bands.</p> <p>The N–C bonds and the C–H bonds do not undergo changes in dipole moment in the presence of infrared radiation.</p>
4	A	
5	C	<p>Infrared radiation causes a change in the dipole moment of sulfur dioxide molecules. A sample collected from air is non-aqueous or may be dried. Non-polar molecules, aqueous samples and ions are not analysed by IR.</p>
6	B	

2.2.7: Mass Spectrometry

No.	Answers	Further explanations
1	C	
2	A	
3	B	

No.	Answers	Further explanations
4	D	The base peak is the tallest peak, which represents the most abundant ion. The ion $-\text{CH}_2\text{OH}^+$ has a mass of 31.
5	A	Pure carbon-12, the reference sample for atomic mass, is exactly 12.00 mass units. It shows only one peak on a mass spectrum.

2.2.8: Chromatographic Methods of Separation

No.	Answers	Further explanations
1	A	Adsorption method of chromatography Stationary phase: a polar solid, for example silica or alumina, attracts polar solutes in the sample. Mobile phase: a liquid dissolves the less strongly adsorbed solute first. Partition method of chromatography Stationary phase: a thin layer of a liquid embedded on an inert support dissolves the solutes in the sample. Mobile phase: when a liquid or inert gas moves over the stationary phase the solute moves between the two phases.
2	C	
3	B	
4	D	
5	A	The amount of a component in a sample is represented by the area under the peak for the component.
6	C	

2.2.9: Phase Separations

No.	Answers	Further explanations
1	B	
2	C	
3	D	

No.	Answers	Further explanations
4	A	<p>A solution of 95.6% ethanol and 4.4% water is an azeotrope and cannot be separated by fractional distillation because the composition of the vapour is the same as the condensed liquid.</p> <p>A mixture with composition 98% ethanol and 2% water separates in steps to produce ethanol and ultimately the azeotrope with 95.6% ethanol and 4.4% water.</p>
5	B	<p>Since equal volumes of both solvents were used, the partition coefficient can be calculated from the masses:</p> $K_{pc} = \frac{\text{proportion of S in the extracting solvent}}{\text{Proportion of S in original solvent}} = \frac{2.9 \text{ g}}{0.1 \text{ g}} = 29 \text{ at r.t.p.}$
6	C	

Module 3: Industry and the Environment

2.3.1: Locating Industrial Plants: Benefits and Risks

No.	Answers	Further explanations
1	B	<p>The more stringent the waste emission guidelines of a country, the more expensive it is for industries to treat waste.</p> <p>High government taxes means higher cost of finished products.</p>
2	A	

2.3.2: Aluminium

No.	Answers	Further explanations
1	C	
2	A	
3	D	<p>Aluminium is a reactive metal when its surface is clean and free of aluminium oxide. Aluminium cookware is anodised to create an unreactive layer of aluminium oxide on the surfaces. The aluminium oxide bonds firmly to the metal surface and prevents further corrosion.</p>
4	B	

2.3.3: Crude Oil

No.	Answers	Further explanations
1	A	
2	D	Long chain alkanes crack to form shorter chain ones and alkenes, for example ethene. The carbon to carbon bond in ethene is the active site for polymerisation to form polyethene.
3	B	
4	C	Kerosene has a boiling point higher than gasoline but lower than diesel. Kerosene is used as fuel for jets, lamps and small burners. Diesel is a fuel for buses, trucks, lorries and some motor cars.
5	C	

2.3.4: Ammonia

No.	Answers	Further explanations
1	D	
2	C	
3	A	
4	B	Synthesis of ammonia from nitrogen gas and hydrogen gas is a reversible and exothermic reaction. Lower temperatures favour formation of ammonia but reduce the rate.
5	A	
6	B	Lichen are living organisms that are composites of fungi, algae and sometime bacteria. They are often seen on tree trunks and their colours vary from grey to green to yellow to red. Some lichen are sensitive to the presence of ammonia in the atmosphere. The appearance of the lichen in a given location is used as an indicator of the general health of the ecosystem.

2.3.5: Ethanol

No.	Answers	Further explanations
1	A	
2	C	Alcohol can pass from a mother's blood to her foetus' blood. In addition, the foetus is much smaller than the mother so the concentration of alcohol in the foetus is higher than in the mother.
3	D	
4	A	
5	A	Plant materials are fermented to produce alcohol. Nutrient-rich residue produced after fermentation, filtration and distillation may be discharged with wastewater. The water used in the condensers to cool the distillate may be discharged at a temperature above that of the environment.

2.3.6: Chlorine

No.	Answers	Further explanations
1	B	The asbestos diaphragm separates the anode compartment with the higher liquid level from the cathode compartment with the lower liquid. Sodium hydroxide is prevented from seeping into the anode compartment where chlorine gas is produced. If the chlorine gas and sodium hydroxide meet they form sodium hypochlorite, sodium chloride and water.
2	A	
3	C	
4	D	
5	B	In some water treatment facilities, chlorine is pumped by technicians directly into the water. For homes and schools, calcium hypochlorite tablets or granules are preferred. $\text{Ca}(\text{ClO})_{2(s)}$ releases ClO^- ions, which is a powerful disinfectant.
6	C	

2.3.7: Sulfuric Acid

No.	Answers	Further explanations
1	C	
2	B	
3	D	The reaction between sulfur trioxide and water to form sulfuric acid is highly exothermic and produces fumes. It is safer to react sulfur trioxide with concentrated sulfuric acid. The oleum formed reacts with water to produce sulfuric acid.
4	A	
5	C	Sulfur dioxide is an acid anhydride. The scrubbers must contain an alkaline solution.

2.3.8: Water

No.	Answers	Further explanations
1	B	
2	C	
3	A	
4	B	Aquatic organisms require dissolved oxygen for respiration. The oxygen concentration needs to be within a limited range because the respiratory organs are sensitive to the oxygen concentrations. Dissolved oxygen also reacts with pollutants, which are usually released in a reduced form. Low levels of dissolved oxygen is an indicator of high chemical and high biochemical oxygen demands.
5	D	
6	C	Turbidity in water is caused by suspended particles. A nephelometer's measurement of the amount of light scattered or reflected by a sample is used to determine the size and quantity of suspended particles.

2.3.9: The Atmosphere

No.	Answers	Further explanations
1	D	In the upper atmosphere, oxygen molecules react with ultraviolet light to produce oxygen atoms which react with other oxygen molecules to produce ozone molecules. In the overall reaction three oxygen molecules and ultraviolet light form two ozone molecules.
2	A	
3	B	
4	C	Ozone is a more powerful oxidising agent than oxygen.
5	D	
6	A	
7	D	

2.3.10: Solid Waste

No.	Answers	Further explanations
1	D	
2	A	The fewer aluminium products that are used; the fewer need to be produced. Using non-disposable baking pans instead of disposable ones is significant because baking is done in a large number of households. This move does not negatively impact quality of life.
3	B	The half-life of the products of nuclear waste varies widely and so does the ideal storage time. The half-life of Plutonium-239 is 24 000 years. Nuclear waste must be isolated until the decay process produces harmless products.
4	C	