Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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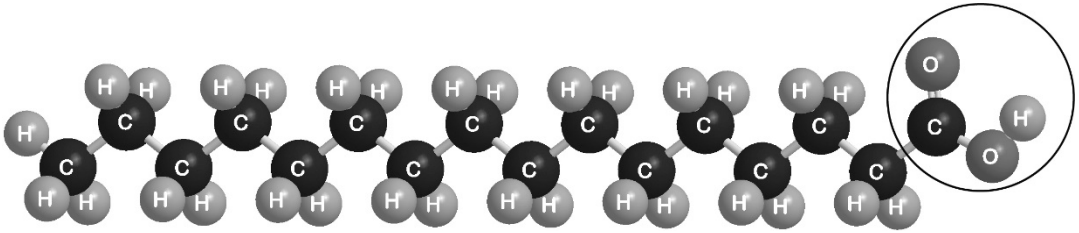
Chemistry

Standard level

Paper 3

22 pages

Section A

Question			Answers	Notes	Total
1.	a	i		*Must cut CH_2–CO bond **AND** enclose all of the –COOH group.*	**1**
1.	a	ii	*Any two of:* –COOH/CO/OH/carboxylate/carboxyl/hydroxyl/hydroxy group forms hydrogen bonds/H-bonds to water ✓ London/dispersion/instantaneous induced dipole-induced dipole forces occur between hydrocarbon chains ✓ hydrocarbon chain cannot form hydrogen bonds/H-bonds to water ✓ strong hydrogen bonds/H-bonds between water molecules exclude hydrocarbon chains «from the body of the water» ✓	*Accept "hydrophilic part/group forms hydrogen bonds/H-bonds to water".* *Accept "hydrophobic section" instead of "hydrocarbon chain".* *Award **[1 max]** for answers based on "the –COOH group being polar **AND** the hydrocarbon chain being non-polar".*	**2 max**

Question			Answers	Notes	Total
1.	b	i	*Above about 240 cm^2:* greater collision frequency/collisions per second between **«**palmitic acid**»** molecules and the barrier **«**as area reduced**»** ✓ *At less than about 240 cm^2:* molecules completely cover the surface ***OR*** there is no space between molecules ***OR*** force from movable barrier transmitted directly through the molecules to the fixed barrier ***OR*** **«**palmitic acid**»** molecules are pushed up/down/out of layer ✓	*For both M1 and M2 accept "particles" for "molecules".* *For M1 accept "space/area between molecules reduced"* ***OR*** *"molecules moving closer together".*	**2**
1.	b	ii	amount of acid = **«**$5.0 \times 10^{-5}\,dm^3 \times 0.0034\,mol\,dm^{-3}$**»** = 1.7×10^{-7} **«**mol**»** ✓ number of molecules = **«**$1.7 \times 10^{-7}\,mol \times 6.02 \times 10^{23}\,mol^{-1}$ =**»** 1.0×10^{17} ✓	*Award* ***[2]*** *for correct final answer.* *Award* ***[1]*** *for "1.0×10^{20}".*	**2**
1.	b	iii	**«**area = $\frac{240\ cm^2}{1.0 \times 10^{17}}$**»** 2.4×10^{-15} **«**cm^2**»** ✓		**1**

Question			Answers	Notes	Total
2.	a		$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$ ✓	*Accept "$CO_2(aq)$".*	1
2.	b		measure the volume of gas at different times «plot a graph and extrapolate» ***OR*** measure the mass of the reaction mixture at different times «plot a graph and extrapolate» ✓	*Accept other techniques that yield data which can be plotted and extrapolated.*	1
2.	c	i	method 2 ***AND*** marble is in excess «so a little extra has little effect» ***OR*** large chips ***AND*** marble is in excess «so a little extra has little effect» ***OR*** method 2 ***AND*** HCl is limiting reagent «so a little extra marble has little effect» ***OR*** large chips ***AND*** HCl is limiting reagent «so a little extra marble has little effect» ✓	*Accept, as a reason, that "as the mass is greater the percentage variation will be lower".*	1
2.	c	ii	surface area ***OR*** purity «of the marble» ✓	*Accept "shape of the chip".*	1
2.	d	i	variation of individual values is much greater «than this uncertainty» ***OR*** «uncertainty» does not take into account «student» reaction time ✓		1
2.	d	ii	$\text{«}\frac{121.96\,\text{s}}{2} = 60.98\,\text{s}\text{»} = 61\text{«s»}$ ✓		1
2.	d	iii	systematic ***AND*** always makes the time shorter «than the actual value» ***OR*** systematic ***AND*** it is an error in the method used «not an individual measurement» ***OR*** systematic ***AND*** more repetitions would not reduce the error ✓	*Accept, as reason, "it always affects the value in the same direction" **OR** "the error is consistent".*	1

Section B

Option A — Materials

Question			Answers	Notes	Total
3.	**a**		«close packed» lattice of metal atoms/ions ✓ no spaces for water molecules to pass though the structure ✓		**2**
3.	**b**	**i**	composite ✓		**1**
3.	**b**	**ii**	melting point ***OR*** permeability ***OR*** density ***OR*** conductivity ***OR*** elasticity/stiffness ***OR*** brittleness/flexibility ***OR*** «tensile» strength ✓	*Accept "colour/transparency".*	**1**

(continued…)

(Question 3b continued)

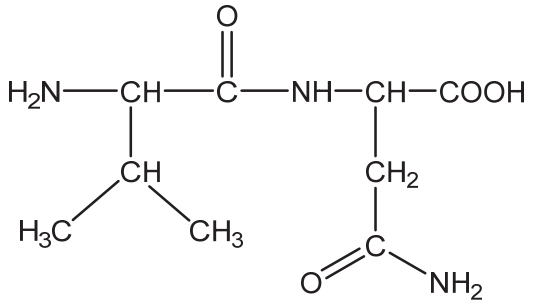
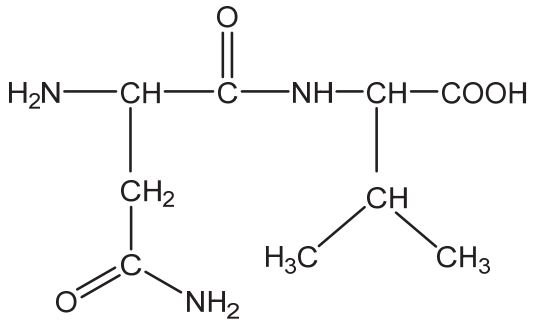
Question			Answers	Notes	Total
3.	**b**	**iii**	*Any three of:* hydrocarbon/carbon-containing gas/compound ✓ mixed with inert gas ✓ heat/high temperature ✓ **«**transition**»** metal catalyst ✓ hydrocarbon/carbon compound decomposes to form carbon **«**nanotubes**»** ✓ nanotubes form on catalyst surface ✓	*Accept "ethanol" or specific hydrocarbons.* *Accept "N_2", "H_2", "NH_3" or specific inert gases.* *Accept temperature or range within 600–800 °C.* *Accept specific metals such as Ni, Co or Fe.*	**3 max**
3.	**b**	**iv**	rod shaped molecules ✓		**1**

Question			Answers	Notes	Total
4.	a		soften/melt when heated ***OR*** can be melted and moulded ✓	*Accept "low melting point" **OR** "can be moulded when heated".*	1
4.	b	i	both have **«**long**»** hydrocarbon chains ***OR*** both have chains comprising CH_2 units ✓ HDPE has little/no branching ***AND*** LDPE has **«**more**»** branching ✓	*Accept "CH_2–CH_2 units".* *Accept "HDPE more crystalline".*	2
4.	b	ii	HDPE is more rigid/less flexible ***OR*** HDPE has a higher melting point ***OR*** HDPE has greater **«**tensile**»** strength ✓	*Accept "HDPE has lower ductility".*	1
4.	c	i	form **«**temporary**»** activated complexes/reaction intermediates ✓	*Accept "consumed in one reaction/step **AND** regenerated in a later reaction/step".* *Accept "provides alternative mechanism".*	1
4.	c	ii	inductively coupled plasma/ICP spectroscopy using mass spectroscopy/mass spectrometry/MS/ICP-MS ***OR*** inductively coupled plasma/ICP spectroscopy using optical emission spectroscopy/OES/ICP-OES ✓	*Accept "atomic absorption/aa spectroscopy" or "MS/mass-spectroscopy/mass spectrometry".*	1

Question			Answers	Notes	Total
4.	**d**		*Any two of:* many types **«**of plastics**»** exist ***OR*** **«**plastics**»** require sorting **«**by type**»** ✓ **«**plastics**»** need to be separated from non-plastic materials ***OR*** **«**often**»** composites/moulded on/bound to non-plastic/other components ✓	*Accept other valid factors such as thermal decomposition of some plastics, production of toxic fumes, etc.*	**2**
4.	**e**		**«**different classifications are appropriate for**»** different properties/applications/ purposes ✓		**1**

5.			ratio of electrons : aluminium ions $= 3 : 1$ ✓ amount Al **«**$\frac{1.296 \times 10^{13}\,\text{C}}{96500\,\text{C mol}^{-1} \times 3}$**»** $= 4.48 \times 10^{7}$ **«**mol**»** ✓ mass Al **«**$= 4.48 \times 10^{7}\,\text{mol} \times 26.98\,\text{g mol}^{-1}$**»** $= 1.21 \times 10^{9}$ **«**g**»** ✓	*Award **[3]** for correct final answer.*	**3**

Option B — Biochemistry

Question			Answers	Notes	Total
6.	**a**		 ***OR***  correct structures of Val ***AND*** Asn ✓ correct amide link ✓		**2**

Question			Answers	Notes	Total
6.	b		*Phenylalanine and valine:* London/dispersion/instantaneous induced dipole-induced dipole forces ***OR*** permanent dipole-induced dipole «interactions» ✓ *Glutamine and asparagine:* hydrogen bonds ✓	*Do **not** accept dipole-dipole interactions.*	2
6.	c	i	hydrolysis ✓		1
6.	c	ii	compare R_f with known amino acids ***OR*** compare distance moved with known amino acids ✓	*Accept "from R_f".*	1
7.	a	i	hydrolytic «rancidity» ✓ ester group ✓	*Accept a formula for ester group.*	2
7.	a	ii	«presence of» moisture/water ***OR*** «increase in» temperature ***OR*** «presence of» enzymes/bacteria/fungi/mould ***OR*** low pH/«presence of» acid ✓	*Accept "heat".*	1

Question			Answers	Notes	Total
7.	b		«stearic acid» straight chain/chain has no kinks/more regular structure ***OR*** «stearic acid» saturated/no «carbon–carbon» double bonds ✓ «stearic acid» chains pack more closely together ✓ stronger London/dispersion/instantaneous induced dipole-induced dipole forces «between molecules» ✓	*Accept "«stearic acid» greater surface area/electron density".*	**3**
7.	c	i	lowers risk of heart disease/atherosclerosis ***OR*** lowers LDL cholesterol ***OR*** increases HDL cholesterol ***OR*** aids brain/neurological development «in children» ***OR*** relieves rheumatoid arthritis ✓		**1**
7.	c	ii	soluble ***AND*** non-polar hydrocarbon chain ✓	*Accept as reasons "«predominantly» non-polar" **OR** "long hydrocarbon chain".*	**1**

(continued)

(Question 7c continued)

Question			Answers	Notes	Total
7.	**c**	**iii**	not biodegradable ***OR*** stored/accumulate in fat ✓ biomagnification occurs ***OR*** concentration increases along food chain ✓	*Accept "stored/accumulate in bodies of prey/animals eaten".* *Accept "not excreted".*	**2**
7.	**c**	**iv**	add starch/cellulose/carbohydrates/additives/catalysts **«**to plastic during manufacture to allow digestion by micro-organisms**»** ***OR*** replace traditional plastics with polylactic acid/PLA-based ones ***OR*** blend traditional and polylactic acid/PLA-based plastics ✓	*Accept reference to biodegradable plastics other than PLA; for example polyhydroxyalkanoates (PHA), poly(butylene succinate) (PBS), polybutylene adipate terephthalate (PBAT) and polycaprolactone (PCL).*	**1**

Question			Answers	Notes	Total
8.	a		«α-1,4-»glycosidic ✓	*Accept «α-1,4-»glycoside.* *Accept "ether".*	1
8.	b		*Glucose:* readily passes through intestine wall/dissolves in blood ***OR*** is immediately available for energy/respiration ***OR*** transported rapidly around body ✓ *Starch:* must be hydrolysed/broken down «into smaller molecules» first ✓		2

Option C — Energy

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>9.</td><td>a</td><td></td><td>
<table>
<tr><th>Gas</th><th>Source</th></tr>
<tr><td>methane/CH_4 ✓</td><td>animals
OR
anaerobic decomposition of organic waste
OR
bogs/marshes/rice paddies ✓</td></tr>
<tr><td>nitrogen(I) oxide/dinitrogen monoxide/N_2O ✓</td><td>bacterial action
OR
combustion of biomass ✓</td></tr>
<tr><td>ozone/O_3 ✓</td><td>effect of UV light on oxygen/O_2 ✓</td></tr>
</table>
</td><td>Accept “nitrous oxide”.

Accept “electrical discharges/lightning”.</td><td>2 max</td></tr>
<tr><td>9.</td><td>b</td><td></td><td>$CO_2\,(aq) + H_2O\,(l) \rightleftharpoons H^+\,(aq) + HCO_3^-\,(aq)$ ✓
OR
$CO_2\,(aq) + H_2O\,(l) \rightleftharpoons H_2CO_3\,(aq)$ AND $H_2CO_3\,(aq) \rightleftharpoons H^+\,(aq) + HCO_3^-\,(aq)$ ✓</td><td>Accept $CO_2\,(aq) + H_2O\,(l) \rightleftharpoons 2H^+\,(aq) + CO_3^{2-}\,(aq)$.

Accept equations with single arrow.</td><td>1</td></tr>
<tr><td>9.</td><td>c</td><td></td><td>no change in polarity/dipole «moment when molecule vibrates» ✓</td><td>Do not accept “non-polar” or “no dipole moment” – idea of change must be there.</td><td>1</td></tr>
</table>

Question			Answers	Notes	Total
10.	**a**		nitrogen/N ***OR*** oxygen/O ***OR*** sulfur/S ✓	*Accept "phosphorus/P".*	**1**
10.	**b**		*Any three of:* different molar masses ***OR*** different strengths of intermolecular forces ✓ different boiling points ✓ temperature in «fractionating» column decreases upwards ✓ «components» condense at different temperatures/heights ***OR*** «component with» lower boiling point leaves column first ✓		**3 max**

Question			Answers	Notes	Total
10.	**c**	**i**	*specific energy* **«** $= \frac{\text{energy released}}{\text{mass consumed}} = \frac{5470\ \text{kJ mol}^{-1}}{114.26\ \text{g mol}^{-1}}$ **»** $= 47.9$ **«**kJ g^{-1}**»** ✓ *energy density* **«** $= \frac{\text{energy released}}{\text{volume consumed}} = \text{specific energy} \times \text{density} = 47.9\ \text{kJ g}^{-1}$ $\times 0.703\ \text{g cm}^{-3}$**»** $= 33.7$ **«**kJ cm^{-3}**»** ✓	*Do **not** accept "–47.9 «kJ g^{-1}»".* *Do **not** accept "–33.7 «kJ cm^{-3}»" unless "–47.9 «kJ g^{-1}»" already penalized.*	**2**
10.	**c**	**ii**	energy is lost **«**to the surroundings**»** as heat/sound/friction ***OR*** energy is lost to the surroundings **«**as heat/sound/friction**»** ***OR*** incomplete combustion ✓	*Do **not** accept just "energy is lost".*	**1**

11.	**a**	**i**	viscosity **«**of vegetable oils is too high**»** ✓ transesterification ***OR*** **«**conversion into**»** alkyl/methyl/ethyl esters ✓		**2**
11.	**a**	**ii**	R–CO–O–CH_3 / RCOOMe ***OR*** R–CO–O–C_2H_5 / RCOOEt ✓		**1**

Question			Answers	Notes	Total
11.	**b**		«growing oil producing» plants absorbs carbon dioxide from the atmosphere ***OR*** «combustion of» petroleum based fuels releases carbon stored «for millions of years» ✓	*Accept "biofuels renewable" **OR** "petroleum based fuels non-renewable".* *Accept "waste vegetable oils can be converted to biofuels/biodiesel".* *Accept "biofuels do not contain sulfur".*	**1**

12.	**a**	**i**	mass spectrometry/mass spectroscopy/MS ✓	*Accept "analysis of radiation emitted".*	**1**
12.	**a**	**ii**	*critical mass:* mass required so that «on average» each fission/reaction results in a further fission/reaction ✓ *Any two for **[2 max]**:* neutron captured by «^{235}U» nucleus ✓ fission/reaction produces many neutrons/more than one neutron ✓ if these cause further fission/reaction a chain reaction occurs ✓	*Accept "minimum mass of fuel needed for the reaction to be self-sustaining".* *Accept answers in the form of suitable diagrams/equations.*	**3 max**
12.	**b**		produce long lived/long half-life radioisotopes/radioactivity ***OR*** could be used to produce nuclear weapons ***OR*** «nuclear» accidents/meltdowns can occur ✓	*Accept "long lived/long half-life radioactive waste".*	**1**

Option D — Medicinal chemistry

Question			Answers	Notes	Total
13.	**a**		*Any one of:* anticoagulant ✓ lower risk of heart attack/strokes ✓ prevent recurrence of heart attack/stroke ✓ prevents cancer of colon/oesophagus/stomach ✓	*Accept "prevents/reduces blood clots" **OR** "blood thinner".*	**1 max**
13.	**b**	**i**	fraction/proportion/percentage **«**of administered dosage**»** that reaches target **«**part of human body**»** ***OR*** fraction/ proportion/percentage **«**of administered dosage**»** that reaches blood **«**plasma**»**/systemic circulation ✓	*Accept "the ability of the drug to be absorbed by the body" **OR** "the extent to which the drug is absorbed by the body".* *Do **not** accept "the amount/quantity of the drug absorbed".*	**1**
13.	**b**	**ii**	**«**intravenous**»** injection/IV ✓	*Accept "parenterally".* *Accept "react with alkali/NaOH" **OR** "convert to ionic form/salt".*	**1**
13.	**c**	**i**	*One absorption found in both spectra:* *Any one of:* 1050–1410 cm^{-1} **«**C–O in alcohols, esters, ethers**»** ✓ 1700–1750 cm^{-1} **«**C=O in carboxylic acids, esters**»** ✓ 2500–3000 cm^{-1} **«**O–H in carboxylic acids**»** ✓ 2850–3090 cm^{-1} **«**C–H in alkanes, alkenes, arenes**»** ✓ *One absorption found in only one of the spectra:* 3200–3600 cm^{-1} **«**O–H in alcohols, phenols**»** ✓	*Award **[1 max]** if candidate states bonds (C=O in both, O–H in salicylic acid only) but doesn't quote wavelength ranges.* *Accept a second/additional absorption at 1700–1750 cm^{-1} from the C=O in ester.*	**2 max**

(continued…)

(Question 13c continued)

Question			Answers	Notes	Total
13.	**c**	**ii**	*Any two of:* ring is **«**sterically**»** strained ***OR*** ring breaks up/opens/reacts **«**easily**»** ***OR*** amide/amido group **«**in ring**»** is **«**highly**»** reactive ✓ **«**irreversibly**»** binds/bonds to enzyme/transpeptidase ***OR*** inhibits enzyme/transpeptidase **«**in bacteria**»** that produces cell walls ***OR*** prevents cross-linking of bacterial cell walls ✓ cells absorb water ***AND*** burst ***OR*** cells cannot reproduce ✓	*Award **[1 max]** for "interferes with cell wall production".* *Do **not** accept "cell membrane" instead of "cell wall".*	**2 max**

(continued…)

(Question 13c continued)

Question			Answers	Notes	Total
13.	**c**	**iii**	*Any two of:* leads to **«**bacterial**»** resistance/proportion of resistant bacteria increases ***OR*** leads to penicillinase-producing bacteria ✓ damage to/contamination of bodies of water/ecosystems ✓ destroys useful/beneficial bacteria ✓ destroyed bacteria replaced by more harmful bacteria ✓	*Accept "endocrine disruptor".* *Do **not** accept "increased cost of developing antibiotics".*	**2 max**
13.	**c**	**iv**	modify side chain ✓		**1**
13.	**d**	**i**	temporarily bind to/block/interfere with receptor sites in brain ***OR*** prevent transmission of pain impulses within CNS/central nervous system ✓		**1**
13.	**d**	**ii**	codeine has a wider therapeutic window ✓	*Accept "codeine has lower activity" **OR** "codeine has lower risk of overdose" **OR** "codeine is less potent" **OR** "codeine has less side-effects".* *Do **not** accept "lower abuse potential for codeine" **OR** "less addictive **«**than morphine**»**" **OR** "codeine has a lower bioavailability" **OR** "available without prescription" **OR** "cheaper".*	**1**

Question			Answers	Notes	Total
14.	**a**	**i**	$MgCO_3(s) + 2HCl(aq) \rightarrow CO_2(g) + H_2O(l) + MgCl_2(aq)$ ✓	*Do **not** accept "H_2CO_3".*	**1**
14.	**a**	**ii**	$n(HCl) = 2\ n(CaCO_3) + 2\ n(MgCO_3)$ ***OR*** $n(HCl) = \frac{2 \times 0.680\ \text{«g»}}{100.09\ \text{«g mol}^{-1}\text{»}} + \frac{2 \times 0.080\ \text{«g»}}{84.32\ \text{«g mol}^{-1}\text{»}}$ ✓ «$n(HCl) = 0.0136\ mol + 0.0019\ mol =$» 0.016 «mol» ✓	*Award **[2]** for correct final answer.* *Award **[1 max]** for correctly calculating amount of acid neutralized by just $CaCO_3$ (0.014 «mol») or $MgCO_3$ (0.002 «mol»).*	**2**
14.	**b**		inhibits the secretion of stomach acid/H^+ ✓ «active metabolites» bind «irreversibly» to «receptors of the» proton pump ✓	*Accept "PPI/proton pump inhibitor".* *Do **not** award mark for "binds to H2/histamine receptors". (Ranitidine mode of action.)* *Accept "H^+/K^+ ATPase" for "proton pump".*	**2**
15.	**a**		blocks/inhibits neuraminidase/NA/«viral» enzyme which allows viruses to pass through cell membrane ✓ prevent virus from leaving/escaping host cell «thus it cannot infect other cells» ✓		**2**
15.	**b**		*Any one of:* limited supply of star anise/plant ✓ «star anise» takes time to grow ✓ time-consuming/multi-step extraction ✓ low concentration in plant ✓	*Accept "low yield for extraction/conversion" **OR** "requires environmentally damaging solvents".*	**1 max**