Markscheme

November 2018

Chemistry

Standard level

Paper 3

25 pages

Section A

	Question		Answers	Notes	Total
1.	**a**		NO_2/NO/NO_x/HNO_3/gas is poisonous/toxic/irritant ✔	*Accept formula or name.* *Accept "HNO_3 is corrosive" **OR** "poisonous/toxic gases produced".* *Accept "reaction is harmful/hazardous".*	**1**
1.	**b**		*Slope (gradient):* 40 ✔ *Equation:* absorbance $= 40 \times$ concentration **OR** $y = 40x$ ✔	*Accept any correct relationship for slope such as $\frac{1.00}{0.025}$.* *Award **[2]** if equation in M2 is correct.*	**2**
1.	**c**		dilute $1.00\,cm^3$ «of the standard solution with water» to $100\,cm^3$ **OR** dilute sample of standard solution «with water» 100 times ✔ «graduated/volumetric» pipette/pipet ✔ volumetric flask ✔	*Accept any 1 : 100 ratio for M1.* *Accept "mix $1\,cm^3$ of the standard solution with $99\,cm^3$ of water" for M1.* *Do **not** accept "add $100\,cm^3$ of water to $1.00\,cm^3$ of standard solution" for M1.* *Accept "burette/buret" for M2.* *Accept "graduated/measuring flask" for M3 but **not** "graduated/measuring cylinder" or "conical/Erlenmeyer flask".*	**3**

Question			Answers	Notes	Total
1.	d	i	concentration of copper = 0.0080 «mol dm^{-3}» ✔	*Accept any value in range 0.0075–0.0085 «mol dm^{-3}» for M1.*	
				Accept annotation on graph for M1.	
			mass of copper in 250.0 cm^3 = «0.0080 mol dm^{-3} × 0.2500 dm^3 × 63.55 g mol^{-1} =» 0.127 «g»		
			OR		
			mass of brass in 1 dm^3 = «4 × 0.200 g =» 0.800 g *AND*		
			[Cu^{2+}] = «0.0080 mol dm^{-3} × 63.55 g mol^{-1} =» 0.5084 g dm^{-3} ✔		**3**
			«% copper in this sample of brass = $\dfrac{0.127}{0.200} \times 100$ =» 64 «%»		
			OR	*Award **[3]** for correct final answer.*	
			«% copper in this sample of brass = $\dfrac{0.5084}{0.800} \times 100$ =» 64 «%» ✔	*Accept "65«%»".*	
1.	d	ii	two ✔	*Do **not** apply ECF from 1(d)(i).*	**1**

Question			Answers	Notes	Total
1.	e	i	«since it is greater than 60%» it will reduce the presence of bacteria «on door handles» ✔		1
1.	e	ii	resistant to corrosion/oxidation/rusting **OR** low friction surface «so ideal for connected moving components» ✔	*Accept "hard/durable", "«high tensile» strength", "unreactive", "malleable" or any reference to the appearance/ colour of brass (eg "gold-like", "looks nice" etc.).* *Do **not** accept irrelevant properties, such as "high melting/boiling point", "non-magnetic", "good heat/electrical conductor", "low volatility", etc.* *Do **not** accept "ductile".*	1
1.	f	i	$2I^- (aq) + 2Cu^{2+} (aq) + 2S_2O_3^{2-} (aq) \rightarrow 2CuI (s) + S_4O_6^{2-} (aq)$ correct reactants and products ✔ balanced equation ✔	*M2 can only be awarded if M1 is correct.*	2
1.	f	ii	precipitate/copper(I) iodide/CuI makes colour change difficult to see **OR** release of I_2/iodine from starch-I_2 complex is slow so titration must be done slowly ✔		1

Section B

Option A — Materials

	Question		Answers	Notes	Total
2.	**a**		$\Delta\chi = 0.7$ **AND** average $\chi = 1.7$ ✔ bonding between metallic and ionic **OR** more than one type of bonding present **OR** bond type difficult to determine as close to several regions/several types/named bonding types **«***eg* ionic and covalent *etc.***»** **OR** bond is mostly covalent **«**based on % covalent scale on diagram**»** **OR** bond has **«** $\dfrac{0.7}{3.2} \times 100 =$**»** 22% ionic character ✔	*Accept "EN" for "χ".* *Accept "bond is ionic but close to several regions/several types/other named bonding type(s) (eg covalent, metallic and covalent etc.)".* *Do **not** accept just "bond is ionic".* *Accept any value for % ionic character in range 15–24% or % covalent character in range 76–85%.*	**2**

Question			Answers	Notes	Total
2.	b	i	*Thermoplastic polymer:* PMA **AND** «weak» intermolecular/IMFs/London/dispersion/van der Walls/vdW/dipole-dipole forces «between layers/chains» **OR** PMA **AND** no/few cross-links «between layers/chains» ✔ *Thermosetting polymer:* Bakelite® **AND** «strong» covalent bonds «between layers/chains» **OR** Bakelite® **AND** extensive cross-links «between layers/chains» ✔	*Do **not** accept "hydrogen bonding" for M1.* *Award [1 max] for correct reasons for both polymer classes even if named polymers are incorrectly classified.*	**2**
2.	b	ii	CH_2CHCl (s) + $2O_2$ (g) $\rightarrow$ HCl (g) + CO (g) + CO_2 (g) + H_2O (g) **OR** CH_2CHCl (s) + O_2 (g) $\rightarrow$ HCl (g) + 2CO (g) + H_2O (g) **AND** 2CO (g) + O_2 (g) $\rightarrow$ CO_2 (g) ✔	*Accept any correctly balanced equation that includes the products specified.*	**1**

	Question		Answers	Notes	Total
2.	c	i	pores/cavities/channels/holes/cage-like structures «in zeolites» have specific shape/size ✔ only reactants «with appropriate size/geometry» fit inside/go through/are activated/can react ✔		2
2.	c	ii	does not require corrosive acid/«concentrated» sulfuric acid/H_2SO_4 **OR** zeolite can be recycled «more easily» **OR** product can be «more» easily separated from a zeolite «than from sulfuric acid» **OR** minimal/less impact on environment **OR** synthesis of specific isomers as products ✔		1
2.	d		*Name and reason:* PET/PETE **AND** peak for $C=O$ «at 1700–1750 cm^{-1}» ✔ *RIC:* 1 ✔	*Accept "PET/PETE **AND** peak for $C-O$ «at 1050–1410 cm^{-1}»" for M1.* *Accept "PET/PETE **AND** peak(s) for COO" for M1.* *Accept name or abbreviation for polymer.* *No ECF for M2.*	2

Question			Answers	Notes	Total
3.	a		positive ions/cations/Pb^{2+} **OR** free electrons ✔	*Accept "ions" **OR** "charged species/particle".*	1
3.	b		$[Pb^{2+}] = 0.50 \times 10^{-6}/5.0 \times 10^{-7}$ **«g dm^{-3}»** ✔ $[Pb^{2+}]$ **«**$= \dfrac{0.50 \times 10^{-6} \text{ g dm}^{-3}}{207.20 \text{ g mol}^{-1}}$ **»** $= 2.4 \times 10^{-9}$ **«mol dm^{-3}»** ✔	*Award **[2]** for correct final answer.*	2
3.	c		**«**Faraday's constant, $F = 9.65 \times 10^4$ C mol^{-1} and $1 \text{ A} = 1 \text{ C s}^{-1}$**»** Q **«**$= 0.0500 \text{ mol} \times 2 \times 96500 \text{ C mol}^{-1}$**»** $= 9650$ **«C»** ✔ t **«**$= \dfrac{Q}{I} = \dfrac{9650 \text{ C}}{1.34 \text{ C s}^{-1}} \approx 7200 \text{ s}$ so $\dfrac{7200 \text{ s}}{60 \times 60 \text{ s h}^{-1}}$ **»** $= 2.00$ **«hours»** ✔	*Award **[2]** for correct final answer.*	2

Question			Answers	Notes	Total
4.	a		*Any two of:* cloudy/foggy/hazy phase «at first melting point» ✔ clear liquid phase «at second melting point/higher temperature» ✔ two «different» melting points *OR* new phase observed over a wide temperature range ✔	*Accept "exhibit both liquid and solid properties at the same time" for M3.*	**2 max**
4.	b		***ALTERNATIVE 1:*** «bulky/long» C_5H_{11}/R/alkyl «group/chain» ***AND*** prevents molecules from packing closer together «to form solid state» ✔ ***ALTERNATIVE 2:*** biphenyl «fragment»/two benzene rings/two aromatic rings ***AND*** «makes molecule» rigid/rod-shaped ✔	*Accept "rigid/rod-shaped molecule, so aligns with other molecules" for* ***ALTERNATIVE 2****.*	**1**
4.	c		«average» oxidation state of C in C_6H_{12}/cyclohexane $= -2$ ***AND*** in CNTs $= 0$ *OR* oxidation state of C in CNTs is higher than in C_6H_{12}/cyclohexane *OR* loss of H's/hydrogens ✔ «oxidation at» anode/positive/+ «electrode» ✔	*Accept "oxidation number" for "oxidation state".*	**2**

Option B — Biochemistry

	Question		Answers	Notes	Total
5.	**a**		catabolism «of food/nutrients» **OR** «cellular» respiration ✔	*Accept "ATP" but **not** "burning of food/nutrients".*	1
5.	**b**		not enough sunlight/UV light «for synthesis of vitamin D in the skin» ✔		1
5.	**c**		cannot be metabolized/broken down **OR** not biodegradable **OR** accumulates in lipid/fat tissues ✔ increased concentration as one species feeds on another «in the food chain» ✔		2

6.	**a**		hydrogen bonding ✔ between C=O and H–N «groups» ✔	*Accept a diagram which shows hydrogen bonding for M1 and which shows the interaction between O of C=O and H of NH groups for M2.* *Accept "between amido/amide/ carboxamide" but **not** "between amino/amine" for M2.*	2

Question			Answers	Notes	Total
6.	b	i	*Enzyme action:* *Any two of:* substrate binds to active site ✔ weakens bonds in substrate ✔ lowers activation energy ***OR*** provides alternate pathway ✔ increases rate of reaction ***OR*** acts as catalyst ✔ substrate specific ✔ *Limitation:* *Any one of:* temperature dependent ✔ pH dependent ✔ can be sensitive to heavy metal ions ✔ sensitive to denaturation ✔ can be inhibited ✔ substrate specific ✔	*Accept "favourable orientation/conformation of the substrate «enforced by enzyme»" for M1.* *Do **not** accept "substrate specific" as both an enzyme action and a limitation.*	**3 max**
6.	b	ii	*Any one of:* «increase rate of» hydrolyse/break down lipids/oils/fats/proteins ✔ «wash at» lower temperature/consume less energy ✔		**1 max**

Question			Answers	Notes	Total
7.	a		phosphoric acid ✔ glycerol/propane-1,2,3-triol ✔	*Do **not** accept formulas.*	**2**
7.	b	i	***ALTERNATIVE 1:*** 4 C=C bonds/4 carbon to carbon double bonds ✔ mass of iodine per mole of acid = «4 × 253.80 g mol^{-1} =» 1015.2 «g mol^{-1}» ✔ iodine number «= $\dfrac{1015.2 \text{ g mol}^{-1}}{276.46 \text{ g mol}^{-1}} \times 100$» = 367 ✔ ***ALTERNATIVE 2:*** 4 C=C bonds/4 carbon to carbon double bonds ✔ «$\dfrac{100 \text{ g}}{276.46 \text{ g mol}^{-1}} \times 4 =$» 1.447 mol of I_2 «reacts with 100 g» ✔ iodine number «= 1.447 mol × 253.80 g mol^{-1}» = 367 ✔	*Award **[3]** for correct final answer.*	**3**
7.	b	ii	*Any two of:* «structural» components of cell membranes ✔ energy storage/utilization ✔ «thermal/electrical» insulation ✔ transport «of lipid-soluble molecules» ✔ hormones/chemical messengers ✔	*Accept other specific functions, such as "prostaglandin/cytokine/bile acid synthesis", "cell differentiation/growth", "myelination", "storage of vitamins/biomolecules", "signal transmission", "protection/padding of organs", "precursors/starting materials for the biosynthesis of other lipid".*	**2 max**

Question			Answers	Notes	Total
7.	**c**		*Any one of:* atherosclerosis/cholesterol deposition «in artery walls» ✔ heart/cardiovascular disease ✔ stroke ✔	*Accept "arteries become blocked/walls become thicker".*	**1 max**

Question			Answers	Notes	Total
8.	**a**		«1,4-»glycosidic ✔	*Do **not** accept "glucosidic".*	**1**
8.	**b**		H and OH are reversed/in different positions on C-4 ✔	*C-4 must be specified.* *Do **not** penalize if reference is made to H and OH above and below ring/in alpha and beta positions on C-4 incorrectly.*	**1**

Option C — Energy

	Question		Answers	Notes	Total
9.	a		small/lighter <u>nuclei</u> combine to form larger/heavier <u>nuclei</u> ✔ product has higher binding energy «per nucleon» ✔	*Accept binding energy curve with explanation.*	2
9.	b	i	converts non-fissile «^{238}U» material into fissile «^{239}Pu» material ***OR*** produces more fissile material than it consumes ✔		1
9.	b	ii	^{239}Pu + ^{1}n → ^{133}Xe + ^{103}Zr + 4^{1}n ✔	*Accept equation with correct atomic numbers included.* *Accept notation for neutrons of "n".* *Accept a correctly described equation in words.*	1
9.	c		***ALTERNATIVE 1:*** « $\dfrac{240}{30}$ =» 8 $t_{\frac{1}{2}}$ /8 half-lives «required» ✔ % remaining = «$0.50^8 \times 100$ =» 0.39 «%» ✔ ***ALTERNATIVE 2:*** $\lambda =$ « $\dfrac{0.693}{30}$ =» 0.023 ✔ % remaining = «$100 \times e^{-0.023 \times 240}$ =» 0.39 «%» ✔	*Award **[2]** for correct final answer.*	2

	Question		Answers	Notes	Total
10.	a		**ALTERNATIVE 1:** $2C\,(s) + 2H_2O\,(g) \rightarrow CH_4\,(g) + CO_2\,(g)$ ✔ **ALTERNATIVE 2:** $C\,(s) + H_2O\,(g) \rightarrow CO\,(g) + H_2\,(g)$ **AND** $3H_2\,(g) + CO\,(g) \rightarrow CH_4\,(g) + H_2O\,(g)$ ✔	*Accept "$3C\,(s) + 2H_2O\,(g) \rightarrow CH_4\,(g) + 2CO\,(g)$".*	1
10.	b	i	«$\dfrac{891\,kJ\,mol^{-1}}{16.05\,g\,mol^{-1}} =$» 55.5 «kJ g^{-1}» ✔	*Do **not** penalize negative sign.* *Do **not** accept energy density at STP/* *density at STP = $\dfrac{39.3}{0.707}$ = 55.06 «kJ g^{-1}».*	1
10.	b	ii	«$\dfrac{141.6}{55.5}$» hydrogen/H$_2$ produces 2.6 times/more than twice the energy of methane/CH$_4$ «per mass/g» **OR** less mass of hydrogen/H$_2$ required «to produce same amount of energy» **OR** hydrogen/H$_2$ more energy efficient ✔	*Accept "hydrogen/H$_2$ produces «nearly» three times more energy than methane/CH$_4$ «per mass/g»".*	1
10.	c		m_{octane} «= 72.0 dm$^3 \times$ 703 g dm^{-3}» = 50600 «g»/50.6 «kg» ✔ $m_{carbon\ dioxide}$ «$= \dfrac{8 \times 44.01}{114.26} \times 50.6$» = 156 «kg» ✔	*Award [2] for correct final answer.*	2

Question			Answers	Notes	Total
11.	**a**		*Advantage:* renewable «energy source» **OR** does not produce greenhouse gases **OR** can be installed «almost» anywhere **OR** low maintenance costs ✔ *Disadvantage:* widely dispersed/not concentrated «form of energy» **OR** geography/weather/seasonal dependent **OR** not available at night **OR** energy storage is difficult/expensive **OR** toxic/hazardous materials used in production **OR** concerns about space/aesthetics/local environment where installed **OR** need to be «constantly» cleaned ✔	*Accept "can be used for passive/active heating", "can be converted to electric energy".* *Accept any specific greenhouse gas name or formula for "greenhouse gases".* *Accept "solar cells require large areas", "solar cell manufacture produces pollution/greenhouse gases", "higher cost of solar cells «compared with traditional sources such as fossil fuels or hydroelectric»".*	**2**

Question			Answers	Notes	Total
11.	**b**		B *AND* larger/more extensive «electronic» conjugation *OR* B *AND* «contains» more alternate single and double bonds ✔	*Accept more specific statements, such as "sp³ carbon in A prevents conjugation between aromatic rings".*	1
11.	**c**	**i**	high viscosity ✔	*Accept "low volatility", just "viscous/viscosity" OR "does not flow easily".*	1
11.	**c**	**ii**	convert to esters of monoatomic alcohols *OR* react with short-chain alcohols «in the presence of acid or base» ✔	*Accept "convert to shorter «carbon chain» esters" OR "transesterification".* *Accept specific alcohols, such as methanol or ethanol.*	1
11.	**d**		carbon dioxide/CO_2 more/most abundant «GHG than methane/CH_4» *OR* carbon dioxide/CO_2 has «much» longer atmospheric life «than methane/CH_4» ✔ methane/CH_4 «much» better/more effective at absorbing IR radiation «than carbon dioxide/CO_2» *OR* methane/CH_4 has a greater greenhouse factor «than carbon dioxide/CO_2» *OR* methane/CH_4 has a greater global warming potential/GWP «than carbon dioxide/CO_2» ✔	*Accept "carbon dioxide/CO_2 contributes more to global warming «than methane/CH_4»".*	2

Question			Answers	Notes	Total
11.	**e**		$CO_2\,(g) + H_2O\,(l) \rightleftharpoons H^+(aq) + HCO_3^-\,(aq)$ **OR** $CO_2\,(g) \rightleftharpoons CO_2\,(aq)$ **AND** $CO_2\,(aq) + H_2O\,(l) \rightleftharpoons H^+(aq) + HCO_3^-\,(aq)$ ✔ «increasing $[CO_2\,(g)]$» shifts equilibrium/reaction to right **AND** pH decreases ✔	*Accept "$H_2CO_3\,(aq)$" for "$CO_2\,(aq) + H_2O\,(l)$".* *Equilibrium arrows required for M1.* *State symbols required for $CO_2\,(g) \rightleftharpoons CO_2\,(aq)$ equation only for M1.* *Accept "concentration of $H^+/[H^+]$ increases **AND** pH decreases" for M2.*	**2**

Option D — Medicinal chemistry

	Question		Answers	Notes	Total
12.	a		<table><tr><td></td><td>Bond angle</td></tr><tr><td>β-lactam ring</td><td>90º ✔</td></tr><tr><td rowspan="3">Expected bond angles</td><td>120º</td></tr><tr><td>AND</td></tr><tr><td>109.5º ✔</td></tr></table>	*Accept "109º".*	2
12.	b		«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 ✔	*Accept "reacts with" for "bonds to" for M1.* *Do **not** accept "cell membrane" for "cell wall" for M1.* *Accept "cells burst due to osmotic pressure" for M2.* *Accept "bacteria" for "cells" for M2.*	2

Question			Answers	Notes	Total
12.	**c**		*Any one of:*	*Accept "superbugs such as MRSA develop" but superbug must be identified.*	**12.**
			leads to «bacterial» resistance «to antibiotics»		
			OR		
			makes antibiotics less effective	*Accept "immune" for resistant but do **not** accept "tolerance"*	
			OR		
			increased side effects due to larger dosages/over time ✔		
			increases proportion of resistant bacteria ✔		**1 max**
			destroys useful/beneficial bacteria		
			OR		
			destroyed bacteria replaced by more harmful bacteria ✔		
			resistant bacteria pass on their mutation to next generation ✔		
			damage to ecosystems ✔		
12.	**d**		«modify» side-chain ✔	*Accept "«modify» R".*	**1**
12.	**e**		no cell walls		**1**
			OR		
			humans do not have transpeptidase ✔		

	Question		Answers	Notes	Total
13.	**a**		blood-brain barrier is hydrophobic/non-polar/made of lipids ✔ morphine has hydroxyl/OH «groups»/is more polar **AND** diamorphine has ester/ethanoate/$OCOCH_3$/acetate «groups»/is less polar/is lipid soluble ✔	*Accept "fats" for "lipid".* *Accept "alcohol/hydroxy" for "hydroxyl" but* **not** *"hydroxide".* *Accept "non-polar" for "less polar" in M2.*	**2**
13.	**b**		«temporarily» binds to «opioid» receptor sites <u>in the brain/CNS</u> **OR** «temporarily» suppresses pain impulses in/to the <u>brain/CNS</u> ✔		**1**
13.	**c**		fraction/proportion/percentage of «administered dosage» enters blood/plasma/circulation ✔	*Accept "fraction/proportion/percentage of «administered dosage» that reaches target «part of human body»".*	**1**

Question			Answers	Notes	Total
14.	a		**ALTERNATIVE 1:** Using: $pH = pK_a + log\left(\dfrac{[A^-]}{[HA]}\right)$ $pK_a = 10.32$ ✔ $pH = «10.32 + log\left(\dfrac{0.0200}{0.0100}\right) =»\ 10.62$ ✔ **ALTERNATIVE 2:** $[H^+]\ «= K_a \times \left(\dfrac{0.0100}{0.0200}\right)» = 2.4 \times 10^{-11}$ ✔ $pH = 10.62$ ✔	Award **[2]** for correct final answer. Accept answers for M2 between 10.6 and 10.7. Award **[1 max]** for pH = 10.02.	2
14.	b		$CaCO_3\,(s) + 2HCl\,(aq) \rightarrow CaCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$ **OR** $CaCO_3\,(s) + 2H^+\,(aq) \rightarrow Ca^{2+}\,(aq) + H_2O\,(l) + CO_2\,(g)$ ✔		1
14.	c		«back» titration **OR** thermal decomposition **OR** atomic absorption/AA ✔	Accept "gravimetric analysis". Do **not** accept description of a technique without proper term given for the technique.	1

Question			Answers	Notes	Total
15.	**a**		bacteria perform living functions «on their own and viruses do not without host cell» *OR* bacteria have cell walls «and viruses do not» *OR* bacteria do not have a capsid «and viruses do» *OR* bacteria larger than viruses *OR* bacteria reproduce by fission/budding «and viruses reproduce within a living host cell» *OR* bacteria affected by antibiotics «while viruses are not» ✔	*Accept "bacteria have flagella/ cytoplasm/ribosome «and virus can have head/protein tail/double stranded RNA/single stranded DNA»", "asexual reproduction for bacteria", other specific structural differences between bacteria and viruses, and examples of living functions that bacteria perform (such as excretion, reproduction etc.) that viruses do not.*	**1**
15.	**b**		*Any two of:* prevents virus attaching to host cell ✔ alters cell's genetic material/DNA «so that virus cannot use it to multiply» ✔ blocks enzyme activity in the host cell «so that virus cannot use it to multiply» ✔ prevents removal of protein coat/capsid ✔ prevents injection of viral DNA/RNA into cell ✔ prevents release of «replicated» viruses from host cell ✔	*Accept "prevents synthesis of virus by host cell".* *Accept "alters RNA/DNA/genetic material of virus".* *Do **not** accept just "mimics nucleotides".*	**2 max**

Question	Answers	Notes	Total
16.	*Any two of:* «weak» C–Cl bonds break/produce radicals ✔ contribute to ozone depletion ✔ contribute to «photochemical» smog ✔ cause cancers ✔ damage respiratory system ✔ cause organ failure ✔ produce toxic chemicals/phosgene/dioxins ✔	 *Accept "chlorinated solvents are toxic".*	**2 max**