M18/4/CHEMI/SP3/ENG/TZ2/XX/M

Diploma Programme
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Chemistry

Standard level

Paper 3

31 pages

Section A

Question			Answers	Notes	Total
1.	a	i	consists of single/one sheet/layer **«**of carbon atoms**»** ✓ graphene has no density measurement ***OR*** graphene has no distance between layers data ***OR*** graphene has large specific surface area **«**compared to graphite**»** ✓	*Do **not** accept "sp^2" alone without reference to single/one sheet/layer.* *Accept "thickness of one atom" **OR** "consists of a plane" for M1.*	**2**
1.	a	ii	*Any one of these alternatives:* ***ALTERNATIVE 1*** **«** $\frac{1.3\times10^{11}}{76\times10^{6}}$ **»** 1.7×10^3/1711 ✓ ***ALTERNATIVE 2*** $1600 \times 76 \times 10^6 = 1.2 \times 10^{11}$ **«**is less than tensile strength of graphene**»** ✓ ***ALTERNATIVE 3*** $\frac{1.3\times10^{11}}{1600} = 8.1 \times 10^7$ **«**is greater than upper end of tensile strength for graphite**»** ✓	*Accept any value in the range 1700–27 083. Answer may be expressed in scientific notation or otherwise.* *Accept any value calculated which is less than the graphene tensile strength based on a value chosen from within the 4.8–76 $\times 10^6$ range.*	**1**

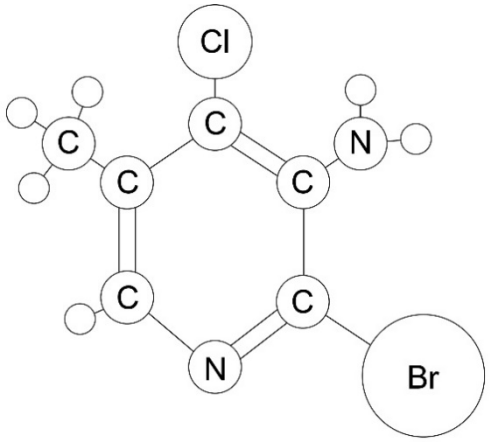
(continued…)

(Question 1a continued)

Question			Answers	Notes	Total
1.	**a**	**iii**	**«**graphene has a high electron mobility of**»** 15 000–200 000 **«**$cm^2\ V^{-1}\ s^{-1}$**»** ✓	*A specific value or range of values must be given.* *Accept any value in the 15 000–200 000 «$cm^2\ V^{-1}\ s^{-1}$» range.*	**1**
1.	**b**		smaller/zero ✓ no delocalized electrons/electrons are bound/electrons not free to move/electrons not free to roam ***OR*** localized electrons **«**in sigma bonds**»** ***OR*** large band gap ✓	*Accept "diamond is a dielectric" **OR** "diamond does **not** conduct electricity" for M2.* *Award **[1 max]** for just "immobile/less mobile".* *Award **[2]** for "electrons immobile **«**in diamond**»** due to the large band gap" **OR** "electrons **«**in diamond**»** immobile since electrons are localized **«**in the sigma bonds**»**".*	**2**

Question			Answers	Notes	Total
1.	c		shorter bonds in graphene ***OR*** bonds in graphene intermediate between single and double ***OR*** bond order in graphene is 1.33 ***OR*** delocalization creates stronger bonds ***OR*** shorter bonds are stronger ✓ stronger/shorter bonds require higher temperature/faster thermal motion to be altered ***OR*** stronger/shorter bonds require greater energy to be broken ✓		**2**

Question			Answers	Notes	Total
2.	a		*Any two of:* *Ethene:* «carbon–carbon» double bond ***AND*** *Ethane:* «carbon–carbon» single bond ✓ ethene has a shorter carbon–carbon bond «than ethane» ✓ *Ethene*: planar/two-dimensional/2-D ***AND*** *Ethane:* tetrahedral «carbons»/ three-dimensional/3-D ***OR*** *Ethene:* each carbon surrounded by three electron domains ***AND*** *Ethane:* each carbon surrounded by four electron domains ***OR*** different molecular geometries/shapes ✓ rotation about carbon–carbon inhibited/blocked in ethene ***AND*** not in ethane ✓ «H–C–C/H–C–H» bond angles different ***OR*** *Ethene:* «bond angles approximately» 120° ***AND*** *Ethane:* 109.5/109°✓	*Do **not** accept "different number of atoms/hydrogens/bonds" etc.* *Accept "Ethene: unsaturated **AND** Ethane: saturated" **OR** "Ethene: has a double bond **AND** Ethane: does not" **OR** "Ethene: two flexible bonds between carbon atoms **AND** Ethane: one".* *Accept any reasonable physical description of the two different molecular models based on a variety of kits for M1.* *For ethene, accept any bond angle in the range 117–122°.* *Award **[2]** if any two of the concepts listed are shown in a correctly labelled or annotated diagram.* *Award **[1 max]** for two correct statements for either molecule but with no comparison given to the other.* *Award **[1 max]** for suitable unlabeled diagrams of both compounds.*	**2 max**

Question			Answers	Notes	Total
2.	b	i	6 carbon atoms labelled in correct positions ✓ both nitrogen atoms labelled in correct positions ✓ bromine ***AND*** chlorine atoms labelled in correct positions ✓  		3

(continued…)

(Question 2b continued)

Question			Answers	Notes	Total
2.	**b**	**ii**	accurate bond angles/lengths can be measured ***OR*** **«**using mathematical functions**»** can calculate expected shapes based on energy minimizations ***OR*** better visualization of possible bond rotations/conformation/modes of vibration ***OR*** can visualize macromolecules/proteins/DNA ***OR*** hydrogen bonding **«**networks**»** can be generated/allows intermolecular forces **«**of attraction**»** to be simulated ***OR*** more variety of visualization representations/can observe space filling ***OR*** can produce an electron density map/electrostatic potential map ***OR*** once model is generated file can be saved for future use/computer models can be shared globally by scientists ***OR*** helps design molecules of biological significance/assists in drug design **«**using libraries**»** ***OR*** can predict molecular interactions with solvents/can predict physical properties/can predict spectral data/can examine crystal structures ***OR*** **«**often**»** easier to construct/modify **«**model**»** ✓	*Accept "precise" for "accurate".* *Accept "computer generated structural representation is normally what is expected in order to be published* **«***in a scientific journal***»".** *Accept "easier to see different sizes of atoms/atomic radii".*	**1**

(continued…)

(Question 2b continued)

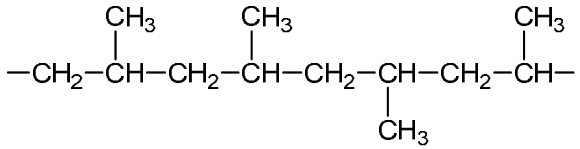
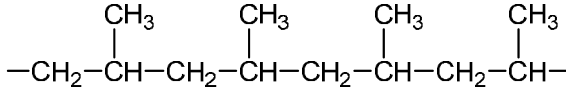
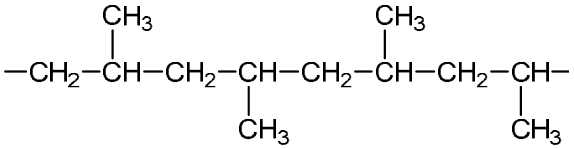
Question			Answers	Notes	Total
2.	**b**	**iii**	bonds within ring have resonance ***OR*** contains delocalized **«**conjugated pi**»** electrons in ring ✓	*There must be reference to a ring or cyclic structure.* *Accept "alternating single and double bonds in a ring".* *Accept "ring which shows resonance/delocalization".* *Accept "follows Hückel/4n +2 rule".* *Do **not** accept "contains one or more benzene rings".*	**1**

Section B

Option A — Materials

Question			Answers	Notes	Total
3.	a		*Alloy:* mixture of metal with other metals/non-metals ***OR*** mixture of elements that retains the properties of a metal ✓ *Composite:* reinforcing phase embedded in matrix phase ✓	*Award **[1 max]** for implying "composites only have heterogeneous/nonhomogeneous compositions".*	**2**
3.	b		effective for yttrium «but less/not for nickel» ✓ points on nickel graph do not lie on «$y = x$» line ***OR*** cannot be used for low concentrations of nickel ***OR*** concentration of nickel is lower than recorded value ✓	*Accept "ICP-OES is more accurate for lower yttrium concentrations than higher concentrations" for M1.* *Accept [Ni] and [Y] for concentrations of nickel and yttrium.* *Accept "detection limit for yttrium is lower than for nickel" for M2.* *Award **[1 max]** for "more accurate for yttrium at lower concentrations **AND** nickel at higher concentrations".*	**2**

Question			Answers	Notes	Total
3.	c	i	*Graph 1:* determines wavelength of maximum absorption/maximum intensity «for vanadium» ✓ *Graph 2:* determines absorption of known concentrations «at that wavelength» ***OR*** estimates [V]/concentration in a sample using «the signal» intensity ✓	*Do **not** accept just "determines maximum wavelength/λ_{max}" for M1.* *Do **not** accept "calibration curve" for M2.*	**2**
3.	c	ii	«$14\,950 = 392.19x + 147.62$» $x = 37.74$ «μg kg^{-1}» ✓	*Answer must be given to **four significant figures**.* *Do **not** accept values obtained directly from the graph.*	**1**
3.	c	iii	vanadium reduced in first reaction ***AND*** oxidized in second reaction ***OR*** V_2O_5 oxidizes SO_2 in first reaction ***AND*** VO_2 reduces O_2 in second reaction ***OR*** vanadium returns to original oxidation state «after reaction» ✓ provides an alternative reaction pathway/mechanism «with a lower activation energy» ✓	*Do **not** accept "reactants adsorb onto surface **AND** products desorb".* *Accept "oxidation number" for "oxidation state".*	**2**

Question			Answers	Notes	Total
4.	**a**		Atactic  ✓ Isotactic  ✓	*Do **not** accept syndiotactic (alternating orientation of the CH_3 groups), eg,*  *for M1 or M2.* *Accept any correct atactic ordering of CH_3 groups.* *Penalize missing hydrogens or incorrect bond connectivities once only.* *Accept skeletal structures.* *Ignore continuation bonds, brackets and "n" indices in structures.*	**2**
4.	**b**	**i**	strong covalent bonds ✓	*Accept "moisture cannot get inside the plastic matrix, and bacteria cannot live without moisture, so they cannot attack the polymer chains".* *Accept "bacteria lack the enzymes required to break down the hydrocarbon chains".*	**1**

(continued…)

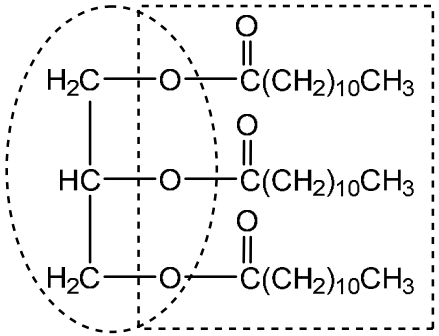
(Question 4b continued)

Question			Answers	Notes	Total
4.	**b**	**ii**	*Any two of:* *Recycling*: shredded/melted/reformed ***AND*** *Reuse*: used in its current form ✓ recycling is more energy intensive **«**than reusing**»** ✓ recycling degrades the quality of plastic but reusing **«**typically**»** does not ✓ recycling breaks down original product to form a new product whereas reuse extends product life ✓		**2**
4.	**c**	**i**	more pliable/flexible materials ***OR*** more durable/non-corrosive/longer-lasting materials ***OR*** greater variety of materials ***OR*** lower density ***OR*** can be clear/translucent ✓	*Accept "more adaptable".* *Do **not** accept just "more useful".*	**1**

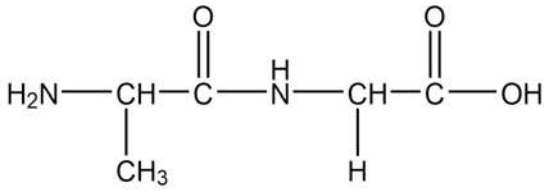
Question			Answers	Notes	Total
5.	**a**		*Arc discharge:* graphite electrode ***OR*** hydrocarbon solvent ✓ *CVD:* gaseous hydrocarbons ✓	*Accept "carbon electrode".* *Accept specific examples of suitable hydrocarbon solvents (eg, methyl benzene/toluene **OR** cyclohexane).* *Accept specific examples of suitable gaseous hydrocarbons (eg, methane, ethane, ethyne/acetylene) **OR** carbon monoxide **OR** carbon dioxide.*	**2**
5.	**b**		*Any three from:* chemically stable ***AND*** does not **«**chemically**»** degrade over time ✓ stable over range of temperatures ***AND*** to avoid **«**voltage/random shift**»** fluctuations ✓ polar ***AND*** influenced by an electric field ✓ strong intermolecular forces ***AND*** allow molecule to align in specific orientations ✓ rapid switching speed/low viscosity ***AND*** change orientation **«**quickly**»** when electric field is applied/reversed ✓	*Award **[1 max]** for identifying three correct properties without any discussion or incorrect interpretation of suitability.* *Accept "voltage" for "electric field".*	**3 max**

Option B — Biochemistry

Question			Answers	Notes	Total
6.	a		*Type of reaction:* condensation ***OR*** esterification/triesterification ***OR*** nucleophilic substitution/nucleophilic displacement/S_N2 ✓ *By-product:* water/H_2O ✓	*Do **not** accept just "substitution/displacement".*	**2**
6.	b		***ALTERNATIVE 1*** «$\frac{334}{253.8}$ =» 1.32 ***AND*** «$\frac{100}{304.5}$ =» 0.328 ✓ «$\frac{1.32}{0.328}$ ≈» 4 ✓ ***ALTERNATIVE 2*** «$334 \times \frac{304.5}{100}$ ≈» 1017 ✓ «$\frac{1017}{253.8}$ ≈» 4 ✓	*Award **[2]** for correct final answer.*	**2**

Question			Answers	Notes	Total
6.	**c**		 glycerol backbone ✓ ester formula ***AND*** linkage ✓	*Accept a skeletal structure.* *Penalize missing hydrogens or incorrect bond connectivities once only in Option B.* *Accept condensed formula for ester.*	**2**
6.	**d**		has affected consumption of *trans*-fats/*cis*-fats/saturated fats/unsaturated fats/ hydrogenated/artificially altered fats ***OR*** reduce/eliminate *trans*-fats/increase in *cis*-fats ***OR*** reduce/eliminate saturated fats ***OR*** increase unsaturated fats ✓	*Do **not** accept "decrease in fat" alone.* *Accept "lipid" for "fats".*	**1**
6.	**e**		«$\frac{29.9\,\text{g}}{150.15\,\text{g mol}^{-1}}$ =» 0.199 «mol» ✓ «0.199 mol × 205.9 kJ mol^{-1} =» 41.0 «kJ» ✓	*Ignore significant figures in M1.* *Award **[2]** for correct final answer.* *Award **[1 max]** for incorrect significant figures in final answer.*	**2**

Question			Answers	Notes	Total
6.	f		ratio of oxygen to carbon in lipids lower ***OR*** lipids less oxidized ***OR*** lipids more reduced ✓ more energy per mass/g released when lipids are oxidized ✓	*Accept "«average» oxidation number of carbon in linoleic acid is lower" for M1.*	**2**

Question			Answers	Notes	Total
7.	a		 peptide bond ✓ order of amino acids ✓	*Accept zwitterion form of dipeptide.* *Accept a condensed structural formula or a skeletal structure.* *Penalize missing hydrogens or incorrect bond connectivities once only in Option B.*	**2**
7.	b		3 ✓		**1**
7.	c		form zwitterions ✓ **«**strong**»** ionic bonding ***OR*** **«**strong**»** ionic lattice ***OR*** **«**strong**»** electrostatic attraction/forces ✓	*Do **not** accept hydrogen bonding or IMFs for M2.*	**2**

Question			Answers	Notes	Total
8.			*Any two of:* replaces plastics with biodegradable/starch/cellulose based plastics ✓ use enzymes instead of polluting detergents/phosphates ***OR*** use of enzymes means lower temperatures can be used ***OR*** use enzymes instead of emulsifiers to treat oil spills ***OR*** use enzymes to produce esters at lower temperatures/without sulfuric acid ✓ replace organic/toxic solvents with carbon dioxide ✓ replace polymers from fossil fuel with bamboo/renewable resources ✓ develop paint resins reducing production of volatile compounds «when paint is applied» ✓ industrial synthesis of ethanoic/acetic acid from methanol and carbon monoxide has 100% atom economy ✓ energy recovery ✓	*Accept formulas for names.* *Award mark for any other reasonable **specific** green chemistry example that prevents the release of pollutants/toxic chemicals into the environment by changing the method or the materials used.* *Do **not** award mark for methods that involve clean-up of pollutants from the environment such as host-guest chemistry or alternative energy sources.*	**2**

Question			Answers	Notes	Total
9.			*Vitamin A:* fat soluble/soluble in non-polar solvents ***AND*** non-polar/long hydrocarbon backbone/chain ✓ *Vitamin C:* water soluble ***AND*** contains 4 hydroxyl groups/contains many hydroxyl groups/forms **«**many**»** H-bonds with water ✓	*Accept "Vitamin A: fat soluble/soluble in non-polar solvents as it contains only one hydroxyl group whose H-bonds with water are not strong enough to overcome London/dispersion/vdW forces between Vitamin A molecules".* *Accept "lipid" for "fats".* *Accept "alcohol" **OR** "hydroxy" **OR** "OH groups" for "hydroxyl" but **not** "hydroxide".* *Award **[1 max]** for "Vitamin A: fat soluble **AND** Vitamin C: water soluble" with no or incomplete explanation.*	**2**

Option C — Energy

Question			Answers	Notes	Total
10.	**a**		*Any two of:* high energy content/high energy density/high specific energy ***OR*** high enthalpy of combustion/very exothermic enthalpy of combustion ✓ shortage of alternatives ***OR*** alternatives are expensive ***OR*** oil is relatively cheap ***OR*** oil is «still» abundant/common ✓ well-established technology ***OR*** easy for consumers to obtain ***OR*** commonly used ✓ easy to store ***OR*** easy to transport ***OR*** easy to extract ✓ produces energy at a reasonable rate ✓	*Accept "high potential energy" for M1.*	**2**

Question			Answers	Notes	Total
10.	**b**	**i**	$C_{16}H_{34}$ (g) $\rightarrow$ C_8H_{16} (g) + C_8H_{18} (g) ***OR*** $C_{16}H_{34}$ (g) + H_2(g) $\rightarrow$ 2 C_8H_{18} (g) ✓		**1**
10.	**b**	**ii**	C_8H_{18} ***AND*** is an alkane ***OR*** C_8H_{18} ***AND*** petrol does not contain alkenes ✓		**1**
10.	**c**	**i**	fuels can be compressed more without undergoing **«**unwanted**»** auto-ignition ✓	*Accept "burns smoother without undergoing «unwanted» auto-ignition"* ***OR*** *"fuel does not auto-ignite".*	**1**
10.	**c**	**ii**	produces more branched chain hydrocarbons **«**with higher octane rating**»** ***OR*** produces aromatics **«**which have higher octane rating**»** ***OR*** produces cyclohexanes **«**which have higher octane rating**»** ✓	*Accept "increase branches".* *Do* ***not*** *accept "produces benzene".* *Do* ***not*** *penalize for "benzene" if penalty applied in 2.b.iii.* *Accept "produces cyclic structures".*	**1**

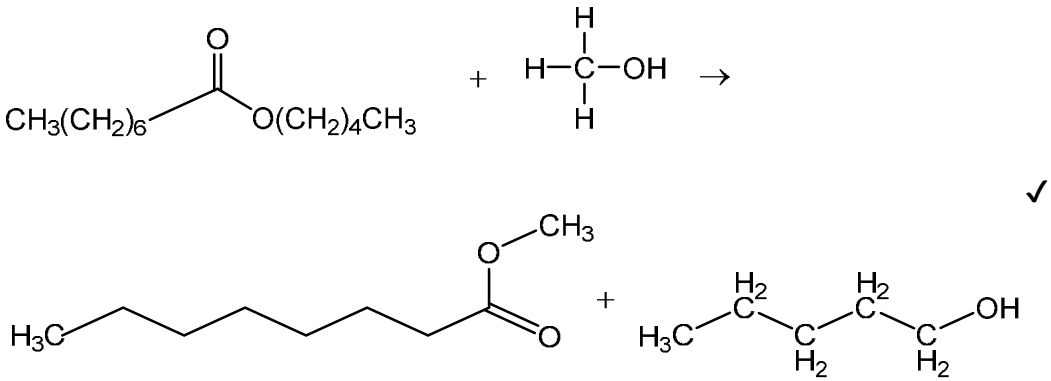
Question			Answers	Notes	Total
11.	a		*Any three of:* IR/long wavelength/low frequency radiation radiated/emitted by the Earth's «surface absorbed in the bonds» ✓ bond length/C=O changes ***OR*** «asymmetric» stretching of bonds ***OR*** bond angle/OCO changes ✓ polarity/dipole «moment» changes ***OR*** dipole «moment» created «when molecule absorbs IR» ✓ «some of» energy is then re-radiated towards «the surface of the» Earth ✓	*Do **not** accept terms such as "reflect" **OR** "bounced" **OR** "trapped".*	**3**

Question			Answers	Notes	Total
11.	b		*Any two of:* H_2O ***AND*** **«**relatively**»** greater abundance/stable concentration/less effective at absorbing radiation/lower GWP so not much overall effect on global warming/climate change ✓ CH_4/N_2O/CFCs/SF_6/O_3/HCFCs ***AND*** more effective **«**than CO_2**»** at absorbing radiation/higher GWP so could contribute to global warming/climate change ✓ PFCs/SF_6/NF_3/Some CFCs ***AND*** have very long life in atmosphere so could contribute **«**in the future**»** to global warming/climate change ✓	*Accept names or formulas.* *Accept two different gases with the same effect for **[2]**.* *Award **[1 max]** for identifying the names/formulas of two greenhouse gases.* *Accept "greenhouse factor" for "GWP" but **not** just "greenhouse effect".* *For M3, do **not** allow "CFC" alone as only some have long lifetimes (eg, CFC-115, CFC-113).*	**2**

12.	**a**		**«** $\frac{813\text{K} - 296\text{K}}{813\text{K}} \times 100$ **»** $= 64$ **«%»** ✓		**1**
12.	**b**		35 % of <u>chemical/potential</u> energy available in coal is transformed to electricity/electrical energy ✓ not all <u>chemical</u> energy from burning fuel transferred into heating water ***OR*** energy dispersed elsewhere/energy lost due to friction of moving parts ***OR*** heat loss to the surroundings ✓	*Accept "stored energy" for "potential energy".*	**2**

Question			Answers	Notes	Total
13.	a		*Award **[1]** for one similarity:* both increase binding energy/energy yield «per nucleon» ***OR*** mass loss/defect in both «nuclear» reactions/mass converted to energy «from $E = mc^2$» ***OR*** both produce ionizing radiation ✓		
			*Award **[2 max]** for any two differences:* in fusion, light nuclei combine to form heavier ones ***AND*** in fission, heavier nuclei split into lighter ones ✓	*Accept "small nuclei" **OR** "smaller atomic masses of nuclei" for "light nuclei" **AND** "large nuclei" **OR** "greater atomic masses of nuclei" for "heavier nuclei".*	
			fission produces radioactive/nuclear waste ***AND*** fusion does not ✓	*Do **not** accept "no/less waste produced for fusion".*	**3**
			fission is caused by bombarding with a neutron «or by spontaneous fission» ***AND*** fusion does not ***OR*** fission can initiate a chain reaction ***AND*** fusion does not ✓		
			fusion releases more energy <u>per unit mass</u> of fuel than fission ✓	*Accept "higher specific energy for fusion".*	
			fuel is easier to obtain/cheaper for fusion reactions ✓		
			fission reactions can be controlled in a power plant ***AND*** fusion cannot «yet» ✓		
			fusion reactor less likely to cause a large-scale technological disaster compared to fission ✓		
			fusion less dangerous than fission as radioactive isotopes produced have short half-lives so only cause a threat for a relatively short period of time ✓		
			fusion is in experimental development ***AND*** fission used commercially ✓		

Question			Answers	Notes	Total
13.	b		$\frac{1}{64} / \frac{1}{2^6} / 0.016$ ✓	*Accept "1.6 %".*	1

14.	a		$C_7H_{15}COOC_5H_{11}$ (l) + CH_3OH (l) → $C_7H_{15}COOCH_3$ (l) + $C_5H_{11}OH$ (l) ***OR*** $C_{13}H_{26}O_2$ (l) + CH_4O (l) → $C_9H_{18}O_2$ (l) + $C_5H_{12}O$ (l) ***OR***  ✓	*Accept correct equation in any format eg, skeletal, condensed structural formula, etc.* *Accept equations with equilibrium arrow.*	1
14.	b		less viscous «and so does not need to be heated to flow» ***OR*** less likely to undergo incomplete combustion ***OR*** fewer intermolecular/London/dispersion forces ***OR*** vaporizes easier ✓	*Ignore equation and products in 14a.* *Accept "van der Waals'/vdW" for "London".*	1

Option D — Medicinal chemistry

Question			Answers	Notes	Total
15.			LD_{50}: amount/dose that kills 50% of the population ✓ TD_{50}: amount/dose that negatively affects/produces toxic effects in 50% of the population ✓	*Award **[1 max]** for "LD_{50} used in animal trials **AND** TD_{50} used in human studies".*	**2**

16.	**a**	**i**	«irreversibly» binds/bonds to enzyme/transpeptidase ***OR*** inhibits enzyme/transpeptidase «in bacteria» that produces cell <u>walls</u> ***OR*** prevents cross-linking of bacterial cell <u>walls</u> ✓ cells absorb water ***AND*** burst ***OR*** cells cannot reproduce ✓		**2**
16.	**a**	**ii**	modify side chain ✓		**1**

Question			Answers	Notes	Total
16.	**b**		condensation ***OR*** esterification ***OR*** nucleophilic substitution/nucleophilic displacement/S_N2 ✓	*Do **not** accept just "substitution/displacement".*	**1**
16.	**c**		water causes hydrolysis ***OR*** aspirin reacts with water ✓ heat increases the rate of hydrolysis ***OR*** heat increases the rate of the reaction with water ✓	*Accept "aspirin will convert into salicylic/ethanoic acid".* *Do **not** accept "aspirin dissolves in water" **OR** "aspirin absorbs water/is hygroscopic".*	**2**

Question			Answers	Notes	Total
17.			morphine has hydroxyl/OH groups/is more polar ***AND*** diamorphine has ester/ethanoate/acetate groups/is less polar/is lipid soluble ✓ crossing blood brain barrier is easier for non-polar/less polar compounds/for lipid soluble compounds ✓	*Accept "alcohol/hydroxy" for "hydroxyl" but **not** "hydroxide".* *Accept "fats" for "lipid".*	**2**

18.	**a**		$2HCl\ (aq) + CaCO_3\ (s) \rightarrow H_2O\ (l) + CO_2\ (g) + CaCl_2\ (aq)$ ✓	*Accept ionic equation:* $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$	**1**
18.	**b**		«$\frac{0.750 \times 2}{100.09}$ =» 0.0150 «mol HCl» ✓		**1**
18.	**c**		inhibits the secretion of stomach acid/H^+ ✓ «active metabolites» bind «irreversibly» to «receptors of the» proton pump ✓	*Do **not** accept "hydrogen/H/H_2" for "H^+".* *Accept "PPI/proton pump inhibitor" for M2.* *Accept "H^+/K^+ ATPase" for "proton pump".*	**2**

Question			Answers	Notes	Total
19.	a		*Any two of:* hydroxyl ✓ carboxyl/carbonyl ✓ ether ✓ amido/carbonyl ✓	*Accept "alcohol/hydroxy" for "hydroxyl", "carboxylic acid" for "carboxyl" and "amide/carboxamide" for "amido".* *Accept "amino/amine" **OR** "imine/imino" but these are not correct as they are part of the guanidino group.* *Accept "alkenyl/alkene/carbon to carbon double bond" but **not** "C=C" **OR** "carbon double bond".* *Accept "carbonyl" only once.* *Accept "heterocyclic ring" for "ether".*	**2**
19.	b		*Any two of:* bacteria perform living functions «on their own» ***AND*** viruses do not «without host cell» ✓ bacteria have cell walls ***AND*** viruses do not ***OR*** bacteria do not have a capsid ***AND*** viruses do✓ bacteria larger than viruses ✓ bacteria reproduce by fission/budding ***AND*** viruses reproduce within a living host cell ✓	*Accept examples of living functions- excretion, reproduction etc for M1.* *Accept "bacteria have flagella/cytoplasm/ribosome **AND** virus can have head/protein tail/double stranded RNA/single stranded DNA".* *Accept other specific structural differences for M2.* *Accept "asexual reproduction for bacteria" for M4.*	**2**

Question			Answers	Notes	Total
20.			*Hazardous solvent:* *Any one of:* methanal/formaldehyde ✓ methanol ✓ chlorinated solvent/carbon tetrachloride/methylene chloride/dichloromethane ✓ diethyl ether/ethoxyethane ✓ benzene ***OR*** methyl benzene/toluene ***OR*** **«**1,2/1,3/1,4**»** dimethylbenzene/**«**ortho/o-/meta/m-/para/p-**»** xylene ✓ *Green solvent:* *Any one of:* water ✓ **«**supercritical/liquid**»** carbon dioxide/supercritical fluids ✓ ethanol **«**only if replacing a hazardous solvent**»** ✓ propan-2-ol/2-propanol/isopropanol **«**only if replacing a hazardous solvent**»** ✓ propanone/acetone **«**only if replacing a hazardous solvent**»** ✓ ethyl ethanoate/ethyl acetate **«**only if replacing a hazardous solvent**»** ✓ organic carbonates/dimethyl carbonate/diethyl carbonate/ethylene carbonate/propylene carbonate ✓ ionic liquids ✓ fluorous solvents ✓	*Accept correct names (either IUPAC or generic) or formulas.* *Do **not** accept inorganic acids such as HCl, H_2SO_4, etc.* *Accept any specific chlorinated solvent.* *Accept other hazardous solvents.* *Do **not** accept any solvent given as **both** hazardous and green.* *Award **[2]** for combination "Hazardous solvent: dimethylformamide/DMF/N,N-dimethylmethanamide" **AND** "Green solvent: methanol «only if replacing a hazardous solvent»".* *Accept other green solvents but **not** "solvents from biomass/food waste".*	**2**