N17/4/CHEMI/HP3/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2017

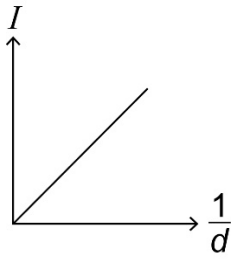
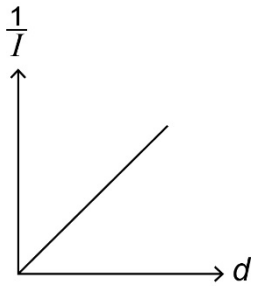
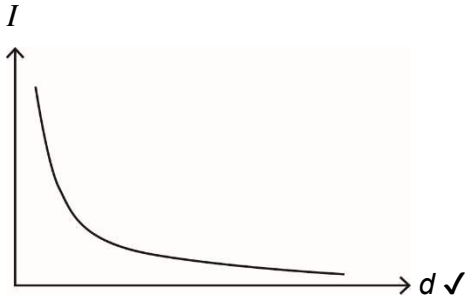
Chemistry

Higher level

Paper 3

37 pages

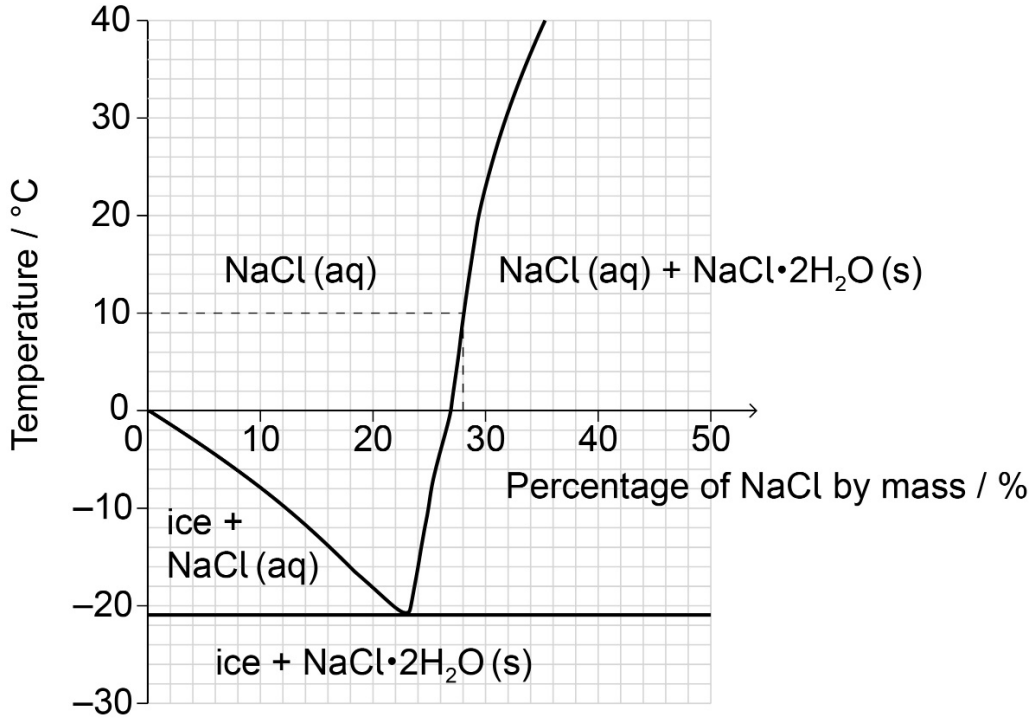
Section A

Question			Answers	Notes	Total
1.	a		 ***OR***  ***OR*** 	*Correct labels of axes required for mark.* *Accept d^{-1} instead of $\frac{1}{d}$.* *Accept I^{-1} instead of $\frac{1}{I}$.* *Plot of I vs d should not be linear.*	**1**

Question			Answers	Notes	Total
1.	b	i	negative correlation ***OR*** model/prediction matches results ***OR*** 99% of variance accounted for ✓		1
1.	b	ii	$I = -0.001631\ d + 0.09939$ ***OR*** $y = -0.001631\ x + 0.09939$ ✓	*Accept correctly rounded values for m and b in equation.* *Do **not** accept "$y = mx + b$".*	1
1.	b	iii	ions move «across electrolyte» ✓		1

Question			Answers	Notes	Total
2.	a		$Mg(OH)_2\,(s) + 2HCl\,(aq) \rightarrow MgCl_2\,(aq) + 2H_2O\,(l)$ ✓	*Accept full or net ionic equation.*	1
2.	b		*Any two from:* volume «of HCl» ✓ concentration «of HCl»/[HCl] ✓ temperature «of HCl» ✓ mass of antacid/tablets ✓ size of antacid particles/tablets ***OR*** surface area of antacid «particles»/tablets ✓	*Accept "number of tablets/different doses".* *Do **not** accept "same pH meter" **OR** "initial pH" **OR** "concentration of antacid/[antacid]".* *A variable must be given so do **not** accept answers such as "stirring", "whether tablets are whole or crushed" etc.*	2 max
2.	c		(±) 0.04 ***OR*** (±) 0.03 ✓		1

Question			Answers	Notes	Total
2.	d		*Any two of:* uncertainty **«**(±)0.04/(±)0.03**»** means **A** and **C** cannot be distinguished ✓ each measurement was conducted once ✓ stomach pH should not be raised a lot **«**so antacid B is not necessarily effective**»** ✓ mass/number of tablets/dose **«**of antacid**»** used was not controlled ✓ actual environment in stomach is different ✓	*Accept "amount of tablets" for "dose".* *Do **not** accept "nature/composition of tablets differs".* *Accept an answer such as "time frame is too short since some antacids could be long-acting drugs if they contain a gelatinisation/delaying agent" but **not** just "time frame is too short since some antacids could be long-acting drugs".*	**2 max**

Question			Answers	Notes	Total
3.	a		–21 «°C» ✓		1
3.	b		 28 «%» ✓	*Accept any specific answer in the range 27 to 29* «%».	1

Question			Answers	Notes	Total
3.	c		$M_r = 94.48$ ✓ «2 $\frac{(1.01 \times 2 + 16.00)}{94.48} \times 100 =$» 38.15 «%» ✓	*Award M2 only if answer is to 2 decimal places.* *Award **[2]** for correct final answer.* *Award **[1 max]** for 38.10 %.*	**2**
3.	d		rust/corrosion «of cars and bridges» ***OR*** waste of important raw material ***OR*** soil/water salination/pollution «from run off» ***OR*** erosion of/damage to the road surface ***OR*** specific example of damage to the ecosystem ***OR*** «outdoor» temperatures may go below effective levels for NaCl «to lower freezing point» so NaCl could be wasted ***OR*** roads can refreeze causing hazards ✓	*Do **not** accept "tyre damage".* *Do **not** accept "economic issues" **OR** "environmental issues" unless specified (eg accept "increase in costs for local councils road budgets" but **not** "cost" alone).* *Do **not** accept "makes roads more slippery".*	**1**

Section B

Option A — Materials

Question			Answers	Notes	Total
4.	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/non-homogeneous compositions".*	**2**
4.	b		difference in ionic/atomic radius prevents layers sliding over each other ✓	*Accept "difference in diameter/packing of cations prevents layers sliding over each other".*	**1**
4.	c		*Any three of:* sample injected into argon «plasma» ✓ atoms «of sample» are excited/ionised ***OR*** electrons are promoted ✓ electrons drop back/recombine with ions ***AND*** emit photons of characteristic energies/wavelengths/frequencies ✓ total number of photons is proportional to concentration of element ✓ actual concentration found from calibration/standard curve ✓	*Accept "graph/plot" for "curve".*	**3 max**

Question			Answers	Notes	Total
5.			*Any two of:* greater selectivity ✓ higher efficiency ✓ longer life expectancy ***OR*** not easily poisoned ✓ easier to recover ✓ low«er» environmental impact ✓ large range of conditions/temperatures/pressures supported ✓ lower energy costs ✓ increase in yield «per unit time» offsets cost of catalyst ✓		**2 max**

Question			Answers	Notes	Total
6.	a		*Any two of:* ability to form a LC phase ✓ chemically stable ✓ «LC phase that is» stable over suitable temperature range ✓ polar ***OR*** being able to change orientation with applied electric field ✓ rapid switching speed **«**responds to changes of voltage quickly**»** ✓	*Accept "ability of molecules to transmit light under certain conditions" **OR** "rod-shaped molecules" **OR** "stable to light/not light sensitive".*	**2 max**
6.	b		*Any two of:* have higher critical temperatures/T_c **«**than Type 1**»** ***OR*** can act at higher temperatures ✓ have higher critical magnetic fields/B_c **«**than Type 1**»** ✓ less time needed to cool to operating temperature ✓ less energy required to cool down/maintain low temperature ✓	*Do **not** accept "Type 2 has a gradual transition to a superconducting state but in Type 1 it is a sharp transition".*	**2 max**
6.	c	i	$Fe(CO)_5(g) \rightarrow Fe(s) + 5CO(g)$ ✓ $2CO(g) \rightarrow C(s) + CO_2(g)$ ✓		**2**
6.	c	ii	large surface area **«**on which carbon nanotubes form**»** ✓		**1**

Question			Answers	Notes	Total
7.	a		branching in LDPE prevents close packing «of chains» ✓ LDPE is more flexible/less rigid ***OR*** LDPE has lower «tensile» strength ✓	*Do **not** accept "difference in density".* *Award **[1 max]** for stating "branching in LDPE **AND** little/no branching in HDPE".*	**2**
7.	b		*addition*: C=C ***AND*** *condensation*: two functional groups needed on each monomer ✓	*Accept "alkene/alkenyl" **OR** "double bond" **OR** "multiple bond".*	**1**
7.	c		hydrogen bonds ✓	*Accept "$\pi-\pi$ stacking/interactions".*	**1**
7.	d		**B** ***AND*** absence of «absorption of» C–H at 2850–3090 «cm^{-1}» ***OR*** **B** ***AND*** presence of «absorption of» C–F at 1000–1400 «cm^{-1}» ✓		**1**
7.	e		$(-C_2H_3Cl-)_2\,(s) + 5O_2\,(g) \rightarrow 4CO_2\,(g) + 2H_2O\,(l) + 2HCl\,(g)$ correct species in reactants and products ✓ balanced ✓	*Accept "$(-C_2H_3Cl-)_2\,(s) + 5.5O_2\,(g) \rightarrow \rightarrow 4CO_2\,(g) + 3H_2O\,(l) + Cl_2\,(g)$".* *Award M2 only if M1 correct.*	**2**

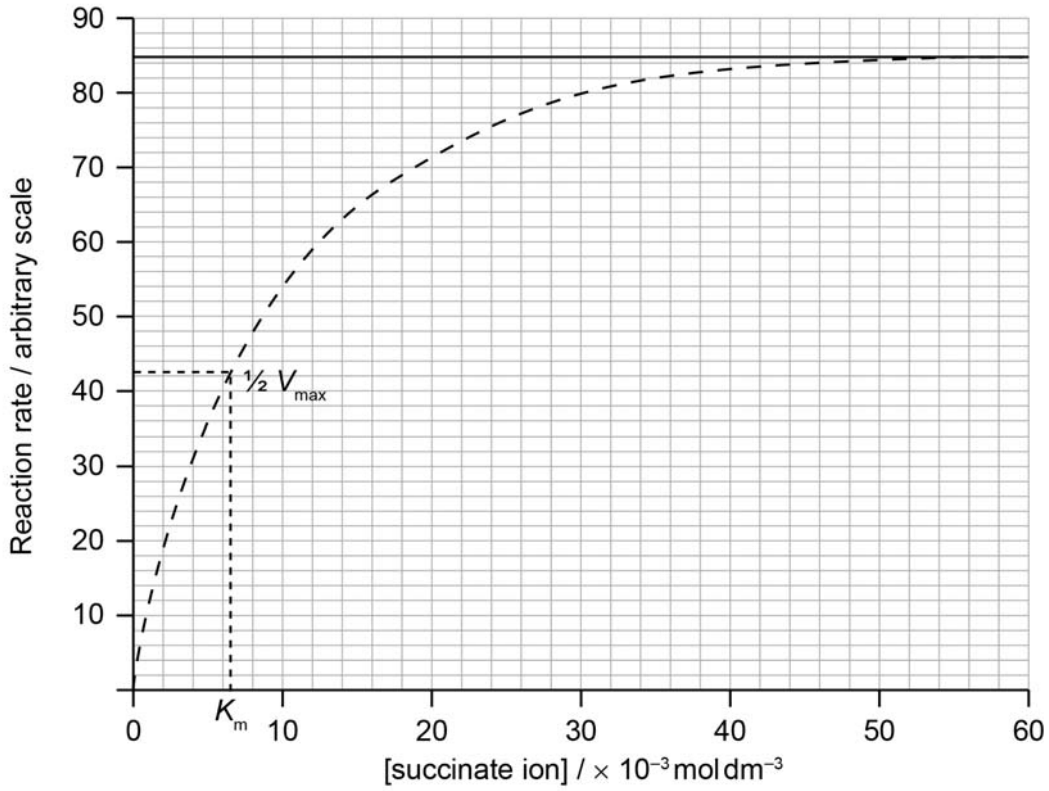
Question			Answers	Notes	Total
8.	a		«$8 \times \frac{1}{8} + 6 \times \frac{1}{2}$ =» 4 ✓		1
8.	b	i	face diagonal = $\sqrt{2}a = 4r$ «$a = \frac{\left(4 \times 1.18 \times 10^{-8}\ \text{cm}\right)}{\sqrt{2}}$ =» 3.34×10^{-8} «cm» ✓		1
8.	b	ii	mass of 4 atoms = $\frac{4 \times 58.93\ \text{gmol}^{-1}}{6.02 \times 10^{23}\ \text{mol}^{-1}} = 3.916 \times 10^{-22}$ «g» ✓ «density = $\frac{3.916 \times 10^{-22}\ \text{g}}{\left(3.34 \times 10^{-8}\ \text{cm}\right)^3}$ =» 10.5 «g cm^{-3}» ✓ *Answer using 3.00 × 10^{-8} cm:* mass of 4 atoms = $\frac{4 \times 58.93\ \text{gmol}^{-1}}{6.02 \times 10^{23}\ \text{mol}^{-1}} = 3.916 \times 10^{-22}$ «g» ✓ «density = $\frac{3.916 \times 10^{-22}\ \text{g}}{\left(3.00 \times 10^{-8}\ \text{cm}\right)^3}$ =» 14.5 «g cm^{-3}» ✓	*Award **[2]** for correct final answer.*	2

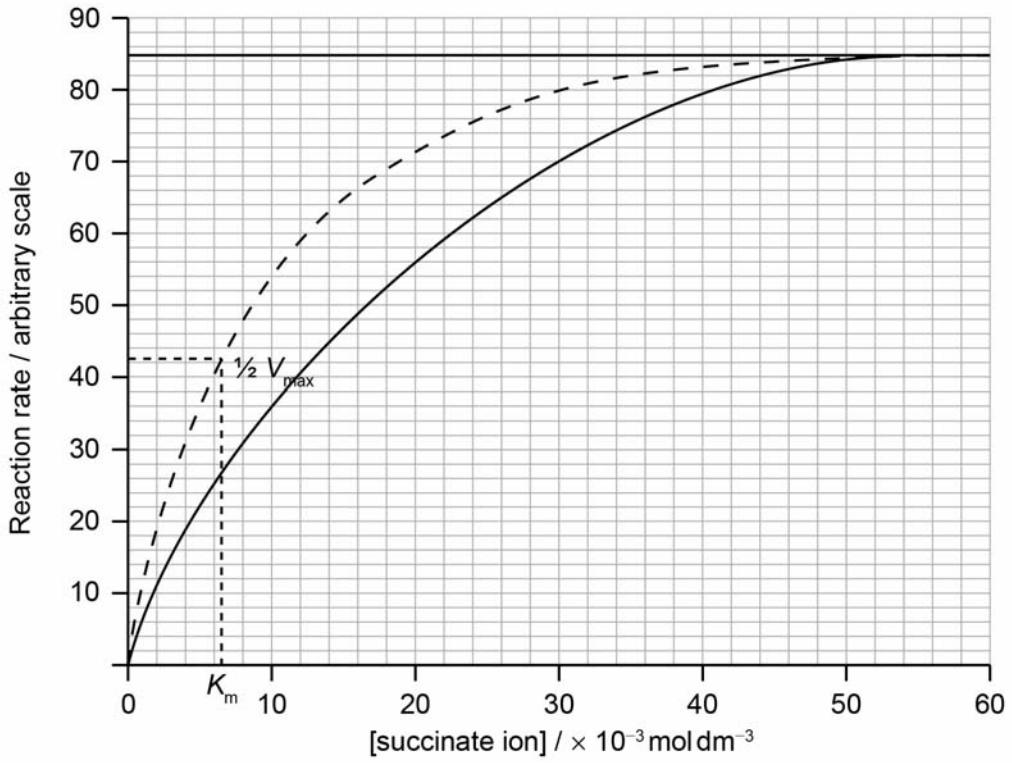
Question			Answers	Notes	Total
9.	**a**		adsorption ***OR*** chelation ***OR*** ion exchange ✓	*Accept other valid methods such as "phytoremediation" **OR** "Fenton reaction" **OR** "electrolysis".*	**1**
9.	**b**		*Calculation:* $K_{sp} = [Cd^{2+}] \times [S^{2-}]$ ✓ $[Cd^{2+}] = 8.0 \times 10^{-26}$ **«**mol dm^{-3}**»** ✓ *Assumption:* volume of solution remains 1.0 dm^3 ***OR*** concentration of sulfide ions in original solution is negligible ***OR*** hydrolysis of sulfide ions is negligible ✓	*Award **[2]** for correct numerical answer of $[Cd^{2+}]$ for M1 and M2.* *Accept "0.10 + x ~ 0.10 «mol dm^{-3}»".*	**3**

Option B — Biochemistry

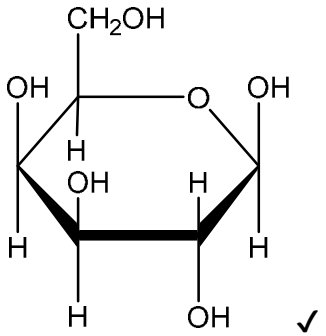
Question			Answers	Notes	Total
10.	**a**	**i**	$C_9H_{16}O$ ✓		**1**
10.	**a**	**ii**	ratio of oxygen to carbon in linoleic acid lower ***OR*** linoleic acid less oxidized ***OR*** linoleic acid more reduced ✓	*Accept «average» oxidation state of carbon in linoleic acid is lower".*	**1**
10.	**b**		«$\frac{1.24\,g}{280.50\,g\,mol^{-1}}$ =» 0.00442 «mol» ✓ 0.00884 mol of C=C ***OR*** ratio of linoleic acid : iodine = 1:2 ✓ «volume of I_2 solution = $\frac{0.00884\,mol}{0.300\,mol\,dm^{-3}}$ =» 0.0295 «dm^3» / 29.5 «cm^3» ✓	*Award **[3]** for correct final answer.*	**3**

Question			Answers	Notes	Total
10.	**c**		*Any two of:* increases **«**ratio of**»** HDL **«**to LDL**»** cholesterol ***OR*** decreases LDL cholesterol **«**level**»** ✓ removes plaque from/unblocks arteries ***OR*** decreases risk of heart disease ✓ decreases risk of stroke **«**in the brain**»** ✓	*Accept "essential fatty acid".* *Do **not** accept "bad cholesterol" for "LDL cholesterol" **OR** "good cholesterol" for "HDL cholesterol".* *Do **not** accept general answers such as "source of energy" **OR** "forms triglycerides" **OR** "regulates permeability of cell membranes" etc.*	**2 max**

Question			Answers	Notes	Total
11.	a		 K_m labelled on x-axis as the [succinate ion] at ½ V_{max} ***OR*** horizontal line at ½ V_{max} ***AND*** vertical line down to x-axis ✓	*Annotation of graph required for M1.*	**2**
			«K_m =» 6.5 × 10^{-3} «mol dm^{-3}» ✓	*Accept any specific value in the range 6.0 × 10^{-3} to 7.5 × 10^{-3} «mol dm^{-3}».*	

Question			Answers	Notes	Total
11.	b	i	similar shape/size/structure «as succinate ion/substrate» ✓ competes for the active site «with the succinate ion/substrate» ✓	*Accept "competitive inhibitor" for M2.* *Award **[1 max]** if non-competitive inhibition is correctly described.*	**2**
11.	b	ii	 same V_{max} reached at higher [substrate] ✓		**1**

Question			Answers	Notes	Total
11.	**c**		conformation/shape altered ***OR*** active site altered ***OR*** tertiary structure altered ✓ acidic/basic/ionizable/COOH/carboxyl/NH_2/amino groups in the R groups/side chains **«**react**»** ✓ exchange/lose/gain protons/H^+ ✓ ionic/H-bonds altered ✓	*Accept "substrate doesn't fit/fits poorly into active site"* ***OR*** *"enzyme denatures" for M1 but* ***not*** *"affects potential of enzyme to form complex with substrate".*	**4**

Question			Answers	Notes	Total
12.	a		«reaction in which» two reactants/molecules/functional groups bond/react «to form a larger molecule/single main product» ✓ small/tiny molecule ***OR*** H_2O formed ✓	*Accept formula or name of a specified small molecule other than water such as ammonia, ethanoic/acetic acid, ethanol, hydrogen sulfide etc. for M2.* *Do **not** accept just "molecule formed".* *Award **[1 max]** for an example giving an equation of a condensation reaction such as the formation of a dissacharide.*	**2**
12.	b		 ✓	*Accept "alpha" or "beta" form of galactose.*	**1**

Question			Answers	Notes	Total
12.	**c**		*Any two of:* makes the plastic more hydrophilic/water soluble ✓ carbohydrates are broken down/hydrolysed by bacteria/microorganisms ✓ makes plastic more accessible to bacteria as holes/channels are created ***OR*** plastic of lower density is more permeable/susceptible to water/oxygen/heat/pressure ✓ weakens intermolecular/London/dispersion/instantaneous induced dipole-induced dipole forces «between polymer chains in the plastic» ✓	*Accept "van der Waals/vdW" for "London" forces.*	**2 max**

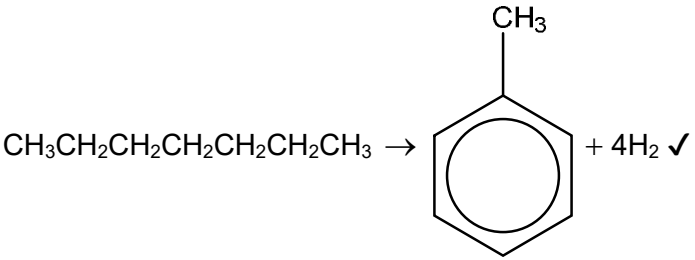
13.			*Water:* hydrogen/H-bonds ***OR*** ion-dipole interactions ✓ *Proteins:* ionic bonds/interactions ***OR*** hydrogen/H-bonds ***OR*** ion-dipole interactions ✓	*Ignore "London/dispersion/vdW/dipole–dipole interactions" stated for water and/or proteins.*	**2**

Question			Answers	Notes	Total
14.	**a**		$O_2 + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ ✓	*Accept any balanced equation with any integer or fractional coefficients.*	**1**
14.	**b**		+2 to +3 ***OR*** +1 ***OR*** increases «by 1» ✓		**1**

Question			Answers	Notes	Total
15.	a		«mainly» hydrocarbon/non-polar «structure» ✓ forms London/dispersion/instantaneous induced dipole-induced dipole forces «with fats» ✓	*Accept "forms van der Waals'/vdW forces".* *Award **[1 max]** for "contains only one OH/hydroxyl **AND** cannot form «enough» H-bonds".*	**2**
15.	b		*Any three of:* *cis*-retinal binds to «the protein» opsin ***OR*** *cis*-retinal «binds to opsin and» forms rhodopsin ✓ rhodopsin extends conjugation in retinal ***OR*** rhodopsin allows absorption of visible/blue/green light ✓ when visible light is absorbed *cis*-retinal changes to *trans*-retinal ✓ change «to *trans*-retinal» triggers an electrical/nerve signal ✓ *trans*-retinal detaches from opsin ***AND*** is converted back to *cis*-retinal ***OR*** *trans*-retinal is converted back to *cis*-retinal through enzyme activity ✓	*Do **not** accept "cis-retinal to trans-retinal" alone without reference to absorption of visible light.*	**3 max**

Option C — Energy

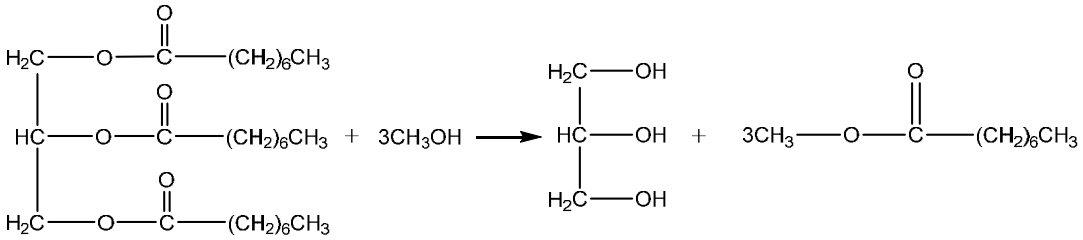
Question			Answers	Notes	Total
16.	**a**		M_r (C_8H_{18}) = 114.26 ***AND*** $\Delta H_c^{\ominus}$ = –5470 **«**kJ mol^{-1}**»** ✓ **«**specific energy = $\frac{5470\text{ kJ}}{0.11426\text{ kg}}$ **=»** 4.79 × 10^4/47873/47900 **«**kJ kg^{-1}**»** ✓	*Award **[2]** for correct final answer.* *Accept "48 × 10^3 **«**kJ kg^{-1}**»**" **OR** "47.9 × 10^3 **«**kJ kg^{-1}**»**".*	**2**
16.	**b**		wood is less useful because it requires **«**about three times**»** more mass for same energy ✓	*Accept "octane is more useful because it has higher specific energy".*	**1**
16.	**c**		*Any one of:* wind ✓ tidal/wave ✓ hydro-electric ✓ solar ✓ thermal/geothermal ✓ plant oil ✓	*Accept "biofuel/biodiesel/«bio»ethanol", but **not** just "water" or "fuel cells".*	**1 max**

Question			Answers	Notes	Total
17.	a		$CH_3CH_2CH_2CH_2CH_2CH_2CH_3 \rightarrow CH_3CH(CH_3)CH_2CH(CH_3)_2$ ***OR***  $CH_3CH_2CH_2CH_2CH_2CH_2CH_3 \rightarrow$ + $4H_2$ ✓ isomerisation/reforming/platforming/cracking ✓ Pt/Re/Rh/Pd/Ir ***OR*** catalyst ✓	*A structural formula is only required for the organic product, not heptane.* *Accept any correctly balanced equation showing increased branching **OR** cyclization **OR** aromatization **OR** cracking.* *Suitable supports for catalysts may be included for M3 (eg silica, alumina, zeolite) but the symbol or name of an appropriate metal must be given (typically a noble metal). Ignore temperature and other conditions.* *Award M2 **AND** M3 for "catalytic isomerisation" **OR** "catalytic reforming" **OR** "catalytic cracking".*	**3**

Question			Answers	Notes	Total
17.	b		which specific carbon-based greenhouse gases are included ***OR*** whether non-carbon based greenhouse gases should be included ***OR*** whether CO/incomplete combustion should be included **«**as can be oxidized to CO_2**»** ***OR*** how to "sum" all steps in a process creating CO_2 ***OR*** difficult to determine both direct and indirect production of GHG/greenhouse gas emissions ✓	*Ignore reference to geopolitical issues (eg false recording of data by governments etc.).* *Accept "difficult to measure all sources of CO_2" but **not** "difficult to measure CO_2 released in atmosphere".*	**1**
17.	c		*Any three of:* incoming solar radiation is short wavelength/high frequency/high energy/UV ✓ radiated/emitted as long wavelength/low frequency/low energy/IR **«**radiation**»** ✓ energy/IR **«**radiation**»** absorbed by **«**bonds in**»** greenhouse gases ✓ energy radiated/emitted as IR **«**radiation**»** some of which returns back to Earth ✓	*Do **not** accept "reflected" **OR** "bounced" **OR** "trapped".*	**3 max**

Question			Answers	Notes	Total
18.	a	i	*Fission:* heavy nuclei ***AND*** *Fusion*: light nuclei ✓ both increase in binding energy/energy yield **«**per nucleon**»** ✓	*Accept "large nuclei" **OR** "greater atomic masses of nuclei" for fission **AND** "small nuclei" **OR** "smaller atomic masses of nuclei" for fusion.* *Award **[1 max]** for "Fission: heavy nuclei **AND** increase in binding energy **«**per nucleon**»**" **OR** "Fusion: light nuclei **AND** increase in binding energy" **«**per nucleon**»**".*	**2**
18.	a	ii	*Any two of:* no/less radioactive waste produced ✓ abundance/low cost of fuel ✓ larger amounts of energy released per unit mass ✓ does not require a critical mass ✓ can be used continuously ✓ fusion reactor less likely to cause large-scale technological disaster ✓	*Do **not** accept "no/less waste produced".* *Accept "higher specific energy".*	**2 max**
18.	b		6 **«**hours**»** ✓		**1**

Question			Answers	Notes	Total
18.	**c**	**i**	*Loss in mass:* **«**$(3.78532 \times 10^{-25}$ kg $- 9.109383 \times 10^{-31}$ kg $- 3.78528 \times 10^{-25}$ kg$) \times 0.00100 \times 6.02 \times 10^{23} =$**»** 1.86×10^{-9} **«**kg**»** ✓ *Energy released:* **«**$E = mc^2 = 1.86 \times 10^{-9}$ kg $\times (3.00 \times 10^8$ m s$^{-1})^2 =$**»** 1.67×10^8 **«**J**»** ✓		**2**
18.	**c**	**ii**	**«**1.67×10^8 J $\times \frac{7}{8} =$**»** 1.46×10^8 **«**J**»** ✓		**1**
18.	**d**		production of radicals/•O_2^-/•OH ***OR*** direct effect such as breaking bonds/atom migration ✓	*Ignore missing dots on radical species.* *Accept named radical eg "superoxide radical"* ***OR*** *"hydroxyl radical".* *An example must be given for second alternative.*	**1**

Question			Answers	Notes	Total
19.	**a**		 ester product ✓ glycerol ***AND*** correct balancing ✓	*Catalyst not required for equation.* *Award M2 only if M1 is correct.*	**2**
19.	**b**		*Any three of:* dye has conjugated system ✓ dye absorbs a photon «and injects an electron into TiO_2» ✓ electrons transferred to semiconductor «and dye ionized» ✓ dye oxidizes/takes electron from electrolyte ✓ electron flows through external circuit «to reduce electrolyte» ✓	*M4 may also be scored from more detailed answers involving iodide species (eg "iodide/I^- oxidized to I_3^-/triiodide" **OR** "I^-/iodide reduces dye" **OR** "I^-/iodide releases electron to dye" **OR** "I_3^-/triiodide reduced to I^-/iodide").*	**3 max**

Question			Answers	Notes	Total
20.	**a**		*Negative electrode (anode):* $CH_3OH\,(aq) + H_2O\,(l) \rightarrow CO_2\,(g) + 6H^+\,(aq) + 6e^-$ ✓ *Positive electrode (cathode):* $O_2\,(g) + 4H^+\,(aq) + 4e^- \rightarrow 2H_2O\,(l)$ ✓ *Overall equation:* $2CH_3OH\,(aq) + 3O_2\,(g) \rightarrow 2CO_2\,(g) + 4H_2O\,(l)$ ✓	*Accept any whole or fractional coefficients in balanced equations.* *Award **[1 max]** for correct half-equations at wrong electrodes for M1 and M2.*	**3**
20.	**b**		*Advantage:* *Any one of:* liquid methanol is easier to transport/store than gaseous hydrogen ***OR*** hydrogen is explosive ✓ longer membrane life «as it operates in aqueous environment» ✓ methanol has greater energy density than hydrogen ✓ *Disadvantage:* *Any one of:* lower voltage ✓ lower power per unit mass «of the cell» ✓ lower efficiency ✓ toxic/can be mistaken for ethanol ✓ lower specific energy ✓	*Ignore any cost references throughout.* *Accept "CO_2/greenhouse gas produced" **OR** "requires a more highly efficient catalyst".* *Do **not** award marks for converse statements for the advantage and disadvantage.*	**2**

Option D — Medicinal chemistry

Question			Answers	Notes	Total
21.	**a**		$^{177}_{71}\text{Lu} \rightarrow {}^{177}_{72}\text{Hf} + {}^{0}_{-1}\text{e}$ **«+ ν»** Hf ✓ correct *A* and *Z* ***AND*** beta product ✓	*Accept "β/ β⁻/e/e⁻" for "$^{0}_{-1}e$".* *Accept "$^{177}Lu \rightarrow {}^{177}Hf + e^{-}$ «+ ν»".*	**2**
21.	**b**		number of half-lives = $\frac{t}{t_{\frac{1}{2}}} = 2.08$ ***OR*** $\frac{N(t)}{N_0} = 0.5^{\frac{14.0}{6.73}}$ ***OR*** $\lambda = \text{«}\frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{6.73} = \text{»}$ 0.103 «day^{-1}» ***OR*** $\frac{N(t)}{N_0} = e^{-0.103 \times 14.0}$ ✓ 23.6 **«%»** ✓	*Award **[2]** for correct final answer.*	**2**

Question			Answers	Notes	Total
21.	c		*Any two of:* emits weak ionising radiation ***OR*** low activity/radioactivity ✓ can be stored until material becomes inactive ***AND*** then disposed with normal waste ✓ «isotopes» have short lives ***OR*** exist for a short period of time ✓	*Award **[1 max]** for "low-level waste/ LLW".*	**2 max**

Question			Answers	Notes	Total
22.	**a**	**i**	C=O ✓	*Accept "carbonyl".*	**1**
22.	**a**	**ii**	**X** (must be identified) ***AND*** *Any two of:* For **X**: N–H **«**absorption**»** ***AND*** at 3300 – 3500 **«**cm^{-1}**»** ✓ O–H **«**absorption**»** in phenol ***AND*** at 3200 – 3600 **«**cm^{-1}**»** ✓ absence of OH **«**absorption**»** in carboxylic acid ***AND*** 2500 – 3000 **«**cm^{-1}**»** ✓	*Accept any specific wavenumber in the range 3300–3380* **«***cm^{-1}***»** *for M1.* *Accept any specific wavenumber in the range 3100–3200* **«***cm^{-1}***»**. *Award* ***[1 max]*** *if* ***Y*** *is incorrectly identified for paracetamol but if a correct reason/reasons is/are given for the bond absorption(s).*	**2 max**
22.	**b**		prevents/interferes with the production of prostaglandins ***OR*** prevents/interferes with the production of substances responsible for inflammation/pain/fever ✓ at the site of injury/source of pain ✓		**2**

Question			Answers	Notes	Total
22.	**c**	**i**	react with CH_3I/methyl iodide **«**in alkaline solution**»** ✓	*Accept "react with CH_3Cl/methyl chloride"* ***OR*** *"react with methyl halide".* *Accept name or formula of a suitable specific methylating reagent (eg trimethylphenylammonium chloride etc.).* *Accept "hydroxy/alcohol" but* ***not*** *"hydroxide" for "hydroxyl".*	**1**
22.	**c**	**ii**	*Any two of:* interact with opioid receptors in the brain ✓ alter the structure of brain cells ***OR*** alter the way the brain works **«**so that it only works normally when the opiates are present**»** ***OR*** prevents transmission of pain impulses inside the brain ✓ release dopamine **«**that the person craves**»** ***OR*** give a feeling of pleasure/euphoria **«**that the person craves**»** ✓ withdrawal symptoms **«**prevent patient from terminating drug use**»** ✓	*Accept specific withdrawal symptoms.*	**2 max**

Question			Answers	Notes	Total
23.	**a**		in animal studies $\frac{\text{LD50}}{\text{ED50}}$ ***AND*** in humans $\frac{\text{TD50}}{\text{ED50}}$ ***OR*** in animal studies lethal dose/LD50 ***AND*** in humans toxic dose/TD50 ✓		**1**
23.	**b**		*Any three of:* chiral auxiliary is optically active ✓ is attached to non-optically active/non-chiral substrate ✓ creates stereochemical condition necessary to follow a certain pathway ✓ allows only the required enantiomer to form «so avoids need to separate a racemic mixture» ✓		**3 max**
23.	**c**		intravenous/IV «injection» ***OR*** injection into the bloodstream ✓		**1**

Question			Answers	Notes	Total
24.			*Any two of:* amido ✓ ether ✓ carbonyl ✓	*Accept "amide/carboxamide".* *Accept "alkenyl/alkene".* *Accept "amino/amine".*	**2 max**

25.	**a**		blocks/binds to H2/histamine receptors **«**in cells of stomach lining**»** ***OR*** prevents histamine molecules binding to H2/histamine receptors **«**and triggering acid secretion**»** ✓ prevents parietal cells from releasing/producing acid ✓	*Accept "H2-receptor antagonist/H2RA"* ***OR*** *"blocks/inhibits action of histamine" for M1.*	**2**
25.	**b**		***ALTERNATIVE 1*** $pH = «pK_a + \log \frac{[A^-]}{[HA]} =» 6.35 + \log (\frac{0.400}{0.0200})$ ✓ **«**pH =**»** 7.65 ✓ ***ALTERNATIVE 2*** $K_a = 4.5 \times 10^{-7}$ ✓ $«K_a = 0.400 \times \frac{[H^+]}{0.0200}$, $[H^+] =» 2.3 \times 10^{-8}$ **«**mol dm^{-3}**»** **«**pH =**»** 7.64 ✓	*Award* ***[2]*** *for correct final answer.* *Do* ***not*** *accept "pH = 8".*	**2**

Question			Answers	Notes	Total
26.			ring is «sterically» strained ***OR*** angles of 90° instead of 109.5/109/120° angles ***OR*** angles smaller than 109.5/109/120°/tetrahedral/trigonal planar/triangular planar angle ✓ ring breaks up/opens/reacts «easily» ***OR*** amido/amide group «in ring» is «highly» reactive ✓ binds to/reacts with/interferes with/inactivates <u>transpeptidase</u> ***OR*** binds to/reacts with/interferes with/inactivates <u>enzyme</u> responsible for bacterial cell wall formation/cross-linking ✓		**3**

27.			ethanol is oxidized «to ethanoic acid» ***OR*** electrons are released ✓ current/potential proportional to concentration «of ethanol» ***OR*** current compared to a reference «to determine concentration» ✓	*Accept "ethanol reacts with oxygen" for M1.* *Accept "voltage" for "potential".*	**2**