

Markscheme

May 2016

Chemistry

Standard level

Paper 3

22 pages

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Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A [**15 marks**] and all questions from **ONE** option in Section B [**20 marks**].
Maximum total = [**35 marks**].

1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative word is indicated in the “Answers” column by a slash (/). Either word can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script. “ECF acceptable” will be displayed in the “Notes” column.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the “Notes” column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the “Notes” column.
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the “Notes” column.
17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the “Notes” column.

Section A

Question		Answers	Notes	Total	
1.	a	ozone: yes because it absorbs IR ✓ oxygen: no because it does not absorb IR ✓		2	
	b	i	Any value in the range: 1300–1500 ✓	(It is in fact 1403 using the same measurement technique as that used to get the data in the table).	1
	b	ii	CCl ₄ : symmetrical/dipoles of C–Cl bonds cancel out OR fluorine/F more electronegative ⟨than chlorine/Cl⟩ OR C–F bond more polar ⟨than C–Cl bond⟩ ✓ ⟨vector⟩ sum of bond polarities in CCl ₃ F non-zero/greater than that in CCl ₄ OR dipoles of ⟨three⟩ C–Cl bonds do not cancel the dipole of C–F bond ✓	Accept suitable diagrams.	2
	b	iii	GWP increases as IR intensity increases ✓	Accept converse statements.	1
	b	iv	no relationship and CO ₂ and CCl ₄ /CF ₄ are non-polar/have zero dipole moment but have very different integrated IR intensities ✓	Accept a plot or sketch with a comment that “changes along x-axis produce random changes along y-axis”.	1
	b	v	⟨data from table such as integrated IR and GWP indicate that they⟩ contribute significantly to global warming ✓ persistent in atmosphere ✓ cause ozone depletion ✓ development ⟨of refrigerants⟩ inadvertently caused problems ✓		2 max

(continued)

Question		Answers	Notes	Total
2.	a	<p>carefully dissolve pellets/handle concentrated solution as corrosive/ reaction exothermic ✓ pour/add ⟨the concentrated solution⟩ to a ⟨1.00 dm³⟩ <u>volumetric flask</u> ✓</p> <p>volumetric flask has low uncertainty in measurement ✓</p> <p>fill up to line/mark/1 dm³ with ⟨dionized/distilled⟩ water when at room temperature OR fill up to line/mark/1 dm³ with ⟨dionized/distilled⟩ water mixing the solution ⟨homogeneously⟩ ✓</p>		2 max
	b	i	blue to green/yellow ✓	1
	b	ii	<p>equivalence point has been exceeded/too much acid has been added ✓</p> <p>calculated concentration increased OR uncertainty increased ✓</p>	2
	c		<p>temperature of NaOH solution changed during experiment OR intensity of colour difficult to detect</p>	<p><i>Accept any valid hypothesis.</i></p> <p>1</p>

(continued)

Section B

Option A — Materials

Question		Answers	Notes	Total
3.	a	$\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g}) \checkmark$		1
	b	<p>Fe_2O_3: paramagnetic and unpaired electrons present so magnetic moments do not cancel out \checkmark</p> <p>Al_2O_3: diamagnetic and electrons are all paired so magnetic moments cancel out \checkmark</p>	Award [1] for " Fe_2O_3 paramagnetic and Al_2O_3 diamagnetic".	2
	c	$n(\text{e}) = \frac{2.00 \times 10^6}{96500} = 20.7 \text{ (mol)}$ <p>OR</p> $n(\text{Al}) = \frac{1}{3} n(\text{e}) = 6.91 \text{ (mol)} \checkmark$ $m(\text{Al}) = (6.91 \times 26.98) \Rightarrow 186 \text{ (g)} \checkmark$	Award [2] for final correct answer.	2
4.	a	<p>possible toxicity (of small (airborne) particles)</p> <p>OR</p> <p>unknown health effects</p> <p>OR</p> <p>immune system/allergy concerns</p> <p>OR</p> <p>uncertain impact on environment \checkmark</p>		1

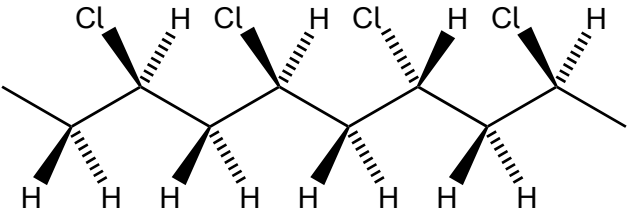
(continued)

(Question 4 continued)

Question		Answers	Notes	Total
	b	<p>EITHER</p> <p>pores/cavities/channels/holes (in zeolites) have specific shape/size ✓ only reactants that fit inside go through/are activated/can react ✓</p> <p>OR</p> <p>zeolites have cage-like structure/are porous ✓ only reactants with appropriate size/geometry fit inside and go through/are activated/can react ✓</p>		2
	c	<p>Catalyst: iron/Fe OR iron(0) (penta)carbonyl/Fe (CO)₅ ✓</p> <p>Conditions: high temperature/900–1600 °C and high pressure/10–100 atm ✓</p>		2
5.		<p>ceramics have giant ionic/covalent structures ✓</p> <p>metals contain lattice of positive metal ions in sea of delocalized electrons ✓</p>		2
6.	a	<p>alters the temperature range of the liquid-crystal state OR alters sensitivity (of the liquid crystal) to electric field(s) OR prevents liquid crystal activity ✓</p>		1

(continued)

(Question 6 continued)

Question		Answers	Notes	Total	
	b	<p>⟨CN group⟩ makes molecule polar ✓</p> <p>alignment/orientation of molecules can be controlled by electric field ✓</p>		2	
7.	a	 <p>correct structure with random orientation of Cl atoms ✓</p>	<p>Accept 2-dimensional diagrams.</p> <p>Accept any arrangement of Cl atoms providing the monomer units originate from chloroethene.</p> <p>Continuation bonds are necessary for the mark.</p>	1	
	b	i	<p>⟨plasticizer molecules⟩ fit between chains OR ⟨plasticizer molecules⟩ increase space between chains ✓</p> <p>weaken intermolecular forces ✓</p>	2	
	b	ii	<p>ester/phthalate/citrate ✓</p>	<p>Accept other general or specific names of plasticizers.</p>	1
	c	<p>does not degrade ⟨so large volume in landfill⟩ ✓</p> <p>concerns about resource waste ✓</p> <p>incineration produces dioxins/toxic compounds ✓</p>		1 max	

Option B — Biochemistry

Question		Answers	Notes	Total
8.	a	<p><i>General hazards:</i> acne OR weight gain OR liver/kidney damage OR stunted growth OR disruption of puberty OR increased aggressiveness OR increased risk of heart disease ✓</p> <p><i>Male hazards:</i> feminization/breast <tissue> development OR shrinking of the testes/testicles OR reduction in sperm production OR impotence ✓</p> <p><i>Female hazards:</i> decreased breast development OR masculinisation OR infertility/abnormal menstrual cycles OR birth defects/altered fetus development ✓</p>	<p>Accept <male pattern> baldness.</p>	<p>3</p>

(continued)

(Question 8 continued)

Question		Answers	Notes	Total
b	i	alkenyl ✓	Accept alkene.	1
b	ii	fused ring structure OR three 6-membered rings and a 5-membered ring OR four-ring «steroidal» backbone ✓		1
c		medical uses of steroids «under physician supervision» OR detection of banned substances has/can be improved OR understanding of the health hazards is improved ✓	Accept any medicalized specific use.	1

9.	a	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th>pH 1.0</th> <th>pH 6.0</th> <th>pH 11.0</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>	pH 1.0	pH 6.0	pH 11.0				Charges must be shown in structure for mark. Penalize repeated mistakes once only.	3
	pH 1.0	pH 6.0	pH 11.0							
b	i	<table style="width: 100%; text-align: center;"> <tr> <td style="width: 33%;">+</td> <td style="width: 33%;">● ● ●</td> <td style="width: 33%;">-</td> </tr> <tr> <td>Glu</td> <td>Leu</td> <td>Lys</td> </tr> </table> <p style="text-align: right;">✓✓</p>	+	● ● ●	-	Glu	Leu	Lys	Award [2] for correct order. Award [1] for Leu in center if order is incorrect.	2
+	● ● ●	-								
Glu	Leu	Lys								

(continued)

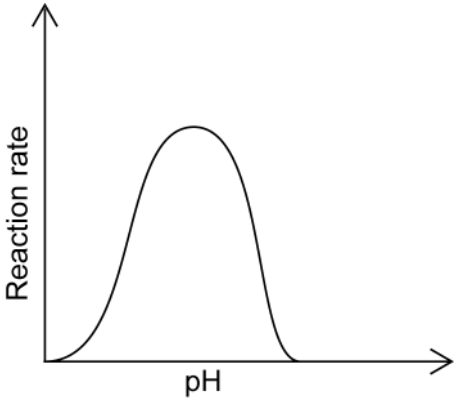
(Question 9 continued)

Question		Answers	Notes	Total
	b ii	6 ✓		1

10.	a	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ ✓		1
	b	$n(C_6H_{12}O_6) \left(= \frac{15.0}{180.18} \right) = 0.0833 \text{ (mol)} \checkmark$ (energy = 0.0833 × 2803 ⇒ 233 (kJ) ✓	<i>Award [2] for correct final answer.</i>	2
	c	<i>Two advantages:</i> renewable resource ✓ broken down by bacteria/other organisms ✓ reduce plastic waste ✓ reduce use of petrochemicals ✓ <i>Two disadvantages:</i> require use of land (crop production) ✓ increase use of fertilizers/pesticides (pollutants) OR eutrophication ✓ might breakdown before end of use ✓ release of methane/greenhouse gas during degradation ✓	Any two for [2 max]. Any two for [2 max].	4 max

(continued)

(Question 10 continued)

Question	Answers	Notes	Total
d	 <p data-bbox="349 683 981 719">bell shaped curve as shown in example above ✓</p>		1

(continued)

Option C — Energy

Question			Answers	Notes	Total
11.	a	i	2,2-dimethylbutane OR 2,3-dimethylbutane OR 3-methylpentane OR 2-methylpentane OR cyclohexane OR methylcyclopentane OR benzene ✓	<i>Accept names or formulas.</i>	1
	a	ii	increased branching OR tertiary free radicals are more stable OR higher octane rating ✓		1
	b	i	$\left\langle \frac{5470}{114.26} \Rightarrow 47.9 \text{ kJ g}^{-1} \right\rangle \checkmark$		1

(continued)

(Question 11 continued)

Question		Answers	Notes	Total
	b ii	<p><i>Advantage:</i> ethanol does not produce particulates OR ethanol has high octane rating OR ethanol is renewable ✓</p> <p><i>Disadvantage:</i> ⟨but⟩ reduces efficiency ⟨as ethanol has lower specific energy⟩ OR ethanol is more volatile ⟨than octane or its isomers⟩ OR land that could be used for food production used to produce crops for ethanol ✓</p>		2
	c	<p>$2\text{C (s)} + 2\text{H}_2\text{O (g)} \rightarrow \text{CH}_4\text{ (g)} + \text{CO}_2\text{ (g)}$ OR $3\text{C (s)} + 2\text{H}_2\text{O (g)} \rightarrow \text{CH}_4\text{ (g)} + 2\text{CO (g)} \checkmark$</p>		1

12.	a	<p><i>Reagent:</i> methanol/CH_3OH OR ethanol/$\text{C}_2\text{H}_5\text{OH}$ ✓</p> <p><i>Catalyst:</i> strong acid OR strong base ✓</p>	<p><i>Accept any strong acid such as sulfuric acid/H_2SO_4.</i></p> <p><i>Accept any strong base such as sodium hydroxide/NaOH.</i></p>	2
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(continued)

(Question 12 continued)

Question		Answers	Notes	Total
	b	$ \begin{array}{c} \text{O} \\ \parallel \\ \text{H}_2\text{C}-\text{O}-\text{C}-\text{R} \\ \\ \text{HC}-\text{O}-\text{C}-\text{R}' \\ \\ \text{O} \\ \parallel \\ \text{H}_2\text{C}-\text{O}-\text{C}-\text{R}'' \end{array} + 3\text{CH}_3\text{OH} \rightleftharpoons $ <p> CH₃OCOR + CH₃OCOR' + CH₃OCOR'' + H₂C(OH)-CH(OH)-CH₂OH </p> <p>correct ester products ✓ formula of glycerol ✓</p>	<p><i>Do not penalize omission of equilibrium sign. Accept use of ethanol/other alcohol as reactant with the corresponding products.</i></p>	2
	c	<p>different solutions can be compared OR best ideas can be shared to arrive at global/local solutions OR acceleration of research <discoveries become available to everyone> OR improved confidence <statistical data can be compared/combined> OR money/effort/time is not wasted duplicating work others have already done ✓</p>		1

13.	a		${}_{90}^{232}\text{Th} + {}_6^{12}\text{C} \rightarrow {}_{96}^{240}\text{Cm} + 4{}_0^1\text{n} \checkmark$	Accept ${}^{232}\text{Th} + {}^{12}\text{C} \rightarrow {}^{240}\text{Cm} + 4\text{n}$.	1
	b	i	<3 half-lives, so> 2.11×10^9 <years> ✓		1

(continued)

(Question 13 continued)

Question		Answers	Notes	Total	
	b	ii	products are radioactive OR products may be used to make <nuclear> weapons ✓	1	
	c		fusion of light nuclei increases energy per nucleon and fission of heavy nuclei increases binding energy per nucleon OR both bring product closer to the maximum binding energy per nucleon <of iron-56> OR both processes result in more stable products ✓	1	
14.			$\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ OR $\text{CO}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{aq})$ and $\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ ✓ increasing $[\text{CO}_2]$ shifts equilibrium to right/increases $[\text{H}^+]$ ✓ pH decreases ✓	Accept $\text{H}_2\text{CO}_3(\text{aq})$ instead of $\text{CO}_2(\text{aq})$. Do not award M1 if states of CO_2 not shown or incorrect.	3
15.			bond length changes/<asymmetric> stretching OR bond angle changes/bends ✓ polarity/dipole moment changes ✓	Accept appropriate diagram.	2

Option D — Medicinal chemistry

Question		Answers	Notes	Total								
16.	a	beta-lactam ring is strained OR ring breaks easily ✓ bonds covalently/interferes with the enzyme/transpeptidase that synthesizes the bacterium cell wall ✓ inhibits cross linking in bacteria cell walls OR bacteria burst (from high osmotic pressure) OR cell cannot reproduce ✓		3								
	b	bacteria can become resistant pollute the environment (overuse in livestock) loss of useful bacteria weakening of the immune system/natural body resistance to diseases ✓	Any two for [1 max].	1								
17.	a	<table border="1"> <thead> <tr> <th>Reagent</th> <th>By-product</th> </tr> </thead> <tbody> <tr> <td>(CH₃CO)₂O OR</td> <td>CH₃COOH OR</td> </tr> <tr> <td>CH₃COCl OR</td> <td>HCl OR</td> </tr> <tr> <td>CH₃COOH ✓</td> <td>H₂O ✓</td> </tr> </tbody> </table>	Reagent	By-product	(CH ₃ CO) ₂ O OR	CH ₃ COOH OR	CH ₃ COCl OR	HCl OR	CH ₃ COOH ✓	H ₂ O ✓	Award M2 if only the by-product correspond to the reagent.	2
Reagent	By-product											
(CH ₃ CO) ₂ O OR	CH ₃ COOH OR											
CH ₃ COCl OR	HCl OR											
CH ₃ COOH ✓	H ₂ O ✓											

(continued)

(Question 17 continued)

Question		Answers	Notes	Total
	b	<p><i>Present in morphine but not in diamorphine:</i> <has OH and absorbance at> 3200–3600 <cm⁻¹> ✓</p> <p><i>Present in diamorphine but not in morphine:</i> <has C=O and absorbance at> 1700–1750 <cm⁻¹> ✓</p>		2
	c	<p>morphine has <two> hydroxyl <groups> and diamorphine/heroin has <two> ester <groups> ✓</p> <p>morphine is more polar than diamorphine/heroin ✓</p> <p>morphine does not cross the blood-brain barrier as well as diamorphine/heroin ✓</p> <p>morphine is better soluble in the blood plasma and diamorphine/heroin is better soluble in lipids ✓</p>	<p><i>Accept converse arguments.</i> Accept “alcohol” for “hydroxyl”.</p>	3 max

18.	a	$\text{Mg(OH)}_2(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{MgCl}_2(\text{aq})$ <p>OR</p> $\text{Mg(OH)}_2(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \checkmark$		1
	b	$\frac{1.00}{58.33} = 0.0171 \text{ <molMg(OH)}_2\text{> } \checkmark$ $\text{<0.0171} \times 2 \times 36.46 \Rightarrow 1.25 \text{ <g> } \checkmark$	<p><i>Award [2] for correct final answer.</i></p>	2

(continued)

(Question 18 continued)

Question		Answers	Notes	Total
	c	<p>both compounds relieve symptoms of acid reflux/heartburn OR both compounds relieve symptoms of indigestion ✓</p> <p>omeprazole stops the production of acid and magnesium hydroxide neutralizes the acid that is present ✓</p> <p>omeprazole takes longer ⟨than magnesium hydroxide⟩ to provide relief OR magnesium hydroxide provides faster relief ⟨than omeprazole⟩ ✓</p> <p>omeprazole can prevent long term damage from overproduction of acid and magnesium hydroxide does not prevent acid damage ✓</p> <p>magnesium hydroxide affects ionic balance in the body/produces ⟨many⟩ side effects and omeprazole does not affect ionic balance/has few⟨er⟩ side effects ✓</p>		3 max

19.	a	<table border="1"> <thead> <tr> <th>Example</th> <th></th> <th>Treatment</th> </tr> </thead> <tbody> <tr> <td>gowns/gloves/syringes/ needles/cotton swabs</td> <td>and</td> <td>storage ⟨in shielded container⟩ until isotope has decayed, then dispose as normal/non-radioactive waste ✓</td> </tr> <tr> <td>radioactive sources/ equipment for external radiotherapy</td> <td>and</td> <td>store <u>underground</u>/bury ✓</td> </tr> </tbody> </table>	Example		Treatment	gowns/gloves/syringes/ needles/cotton swabs	and	storage ⟨in shielded container⟩ until isotope has decayed, then dispose as normal/non-radioactive waste ✓	radioactive sources/ equipment for external radiotherapy	and	store <u>underground</u> /bury ✓	<p><i>Award 1 mark for example and corresponding treatment.</i></p> <p><i>Award [1 max] for the two types of waste.</i></p>	2
		Example		Treatment									
gowns/gloves/syringes/ needles/cotton swabs	and	storage ⟨in shielded container⟩ until isotope has decayed, then dispose as normal/non-radioactive waste ✓											
radioactive sources/ equipment for external radiotherapy	and	store <u>underground</u> /bury ✓											

(continued)

(Question 19 continued)

Question		Answers	Notes	Total
	b	risk vs benefit (patient and environment) OR security OR cultural resistance/superstition/lack of education ✓		1
