Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2016

Chemistry

Standard level

Paper 3

22 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

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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 <u>underlined</u> 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_3F 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		carefully dissolve pellets/handle concentrated solution as corrosive/ reaction exothermic ✓ pour/add ‹the concentrated solution› to a ‹1.00 dm^3› <u>volumetric flask</u> ✓ volumetric flask has low uncertainty in measurement ✓ fill up to line/mark/1 dm^3 with ‹dionized/distilled› water when at room temperature ***OR*** fill up to line/mark/1 dm^3 with ‹dionized/distilled› water mixing the solution ‹homogeneously› ✓		**2 max**
	b	**i**	blue to green/yellow ✓		**1**
	b	**ii**	equivalence point has been exceeded/too much acid has been added ✓ calculated concentration increased ***OR*** uncertainty increased ✓		**2**
	c		temperature of NaOH solution changed during experiment ***OR*** intensity of colour difficult to detect	*Accept any valid hypothesis.*	**1**

(continued)

Section B

Option A — Materials

Question			Answers	Notes	Total
3.	a		$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$ ✓		1
	b		*Fe_2O_3:* paramagnetic **and** unpaired electrons present so magnetic moments do not cancel out ✓ *Al_2O_3:* diamagnetic **and** electrons are all paired so magnetic moments cancel out ✓	*Award **[1]** for "Fe_2O_3 paramagnetic and Al_2O_3 diamagnetic".*	2
	c		$n(e) = \frac{2.00 \times 10^6}{96500} = 20.7$ ‹mol› ***OR*** $n(Al) = \frac{1}{3} n(e) = 6.91$ ‹mol› ✓ $m(Al) =$ ‹$6.91 \times 26.98 =$› 186 ‹g› ✓	*Award **[2]** for final correct answer.*	2

4.	a		possible toxicity ‹of small (airborne) particles› ***OR*** unknown health effects ***OR*** immune system/allergy concerns ***OR*** uncertain impact on environment ✓		1

(continued)

(Question 4 continued)

Question			Answers	Notes	Total
	b		***EITHER*** pores/cavities/channels/holes ‹in zeolites› have specific shape/size ✓ only reactants that fit inside go through/are activated/can react ✓ ***OR*** zeolites have cage-like structure/are porous ✓ only reactants with appropriate size/geometry fit inside **and** go through/are activated/can react ✓		**2**
	c		*Catalyst:* iron/Fe ***OR*** iron‹0› ‹penta›carbonyl/Fe$(CO)_5$ ✓ *Conditions:* high temperature/900–1600 °C **and** high pressure/10–100 atm ✓		**2**

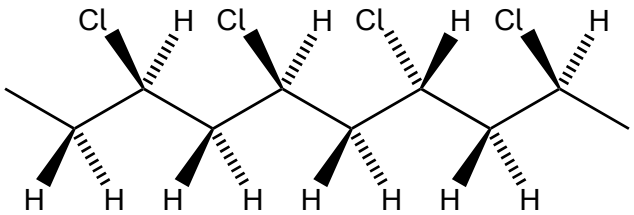
5.			ceramics have giant ionic/covalent structures ✓ metals contain lattice of positive metal ions in sea of delocalized electrons ✓		**2**

6.	**a**		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 ✓		**1**

(continued)

(Question 6 continued)

Question			Answers	Notes	Total
	b		‹CN group› makes molecule polar ✓ alignment/orientation of molecules can be controlled by electric field ✓		**2**

7.	**a**		 correct structure with random orientation of Cl atoms ✓	*Accept 2-dimensional diagrams.* *Accept any arrangement of Cl atoms providing the monomer units originate from chloroethene.* *Continuation bonds are necessary for the mark.*	**1**
	b	**i**	‹plasticizer molecules› fit between chains ***OR*** ‹plasticizer molecules› increase space between chains ✓ weaken intermolecular forces ✓		**2**
	b	**ii**	ester/phthalate/citrate ✓	*Accept other general or specific names of plasticizers.*	**1**
	c		does not degrade ‹so large volume in landfill› ✓ concerns about resource waste ✓ incineration produces dioxins/toxic compounds ✓		**1 max**

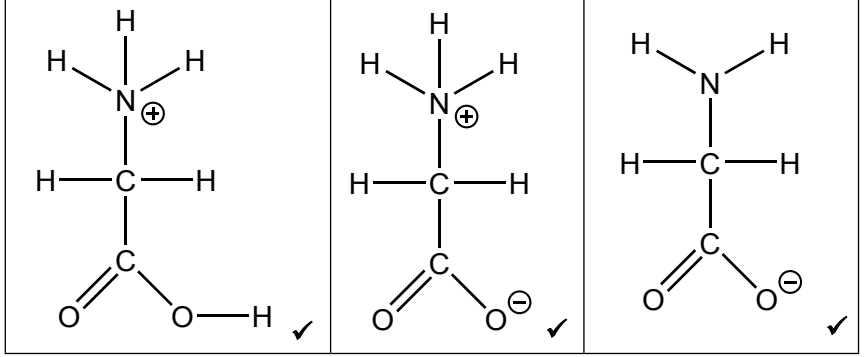
Option B — Biochemistry

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

(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**		pH 1.0 / pH 6.0 / pH 11.0  ✓ ✓ ✓	*Charges must be shown in structure for mark.* *Penalize repeated mistakes once only.*	**3**
	b	**i**	 ✓✓	*Award **[2]** for correct order.* *Award **[1]** for Leu in center if order is incorrect.*	**2**

(continued)

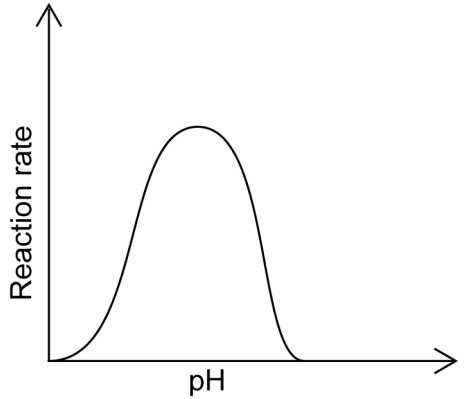
(Question 9 continued)

Question			Answers	Notes	Total
	b	**ii**	6 ✓		**1**

10.	**a**		$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ ✓		**1**
	b		$n(C_6H_{12}O_6)\left(= \frac{15.0}{180.18}\right) = 0.0833$ ‹mol› ✓ ‹energy $= 0.0833 \times 2803 =$› 233 ‹kJ› ✓	*Award **[2]** for correct final answer.*	**2**
	c		*Two advantages:* renewable resource ✓ broken down by bacteria/other organisms ✓ reduce plastic waste ✓ reduce use of petrochemicals ✓ *Two disadvantages:* 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		 bell shaped curve as shown in example above ✓		**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 ✓	*Accept names or formulas.*	**1**
	a	**ii**	increased branching ***OR*** tertiary free radicals are more stable ***OR*** higher octane rating ✓		**1**
	b	**i**	$\left(\frac{5470}{114.26} = \right) 47.9 \left(\text{kJ g}^{-1}\right)$ ✓		**1**

(continued)

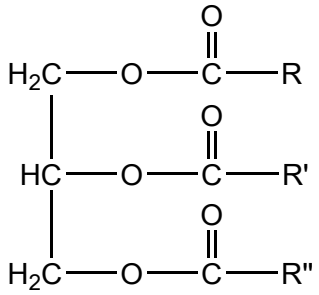
(Question 11 continued)

Question			Answers	Notes	Total
	b	**ii**	*Advantage:* ethanol does not produce particulates ***OR*** ethanol has high octane rating ***OR*** ethanol is renewable ✓ *Disadvantage:* **❮**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 ✓		**2**
	c		$2C(s) + 2H_2O(g) \rightarrow CH_4(g) + CO_2(g)$ ***OR*** $3C(s) + 2H_2O(g) \rightarrow CH_4(g) + 2CO(g)$ ✓		**1**

12.	**a**		*Reagent:* methanol/CH_3OH ***OR*** ethanol/C_2H_5OH ✓ *Catalyst:* strong acid ***OR*** strong base ✓	*Accept any strong acid such as sulfuric acid/H_2SO_4.* *Accept any strong base such as sodium hydroxide/NaOH.*	**2**

(continued)

(Question 12 continued)

Question			Answers	Notes	Total
	b		 $+ 3CH_3OH \rightleftharpoons$ $CH_3OCOR + CH_3OCOR' + CH_3OCOR'' + H_2C(OH)–CH(OH)–CH_2OH$ correct ester products ✓ formula of glycerol ✓	*Do not penalize omission of equilibrium sign. Accept use of ethanol/other alcohol as reactant with the corresponding products.*	**2**
	c		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 ✓		**1**

13.	**a**		${}^{232}_{90}Th + {}^{12}_{6}C \rightarrow {}^{240}_{96}Cm + 4\,{}^{1}_{0}n$ ✓	*Accept* $^{232}Th + {}^{12}C \rightarrow {}^{240}Cm + 4n$.	**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.			$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ ***OR*** $CO_2(g) \rightleftharpoons CO_2(aq)$ **and** $CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ ✓ increasing $[CO_2]$ shifts equilibrium to right/increases $[H^+]$ ✓ pH decreases ✓	*Accept $H_2CO_3(aq)$ instead of $CO_2(aq)$.* *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><tr><th>Reagent</th><th>By-product</th></tr><tr><td>$(CH_3CO)_2O$ ***OR*** CH_3COCl ***OR*** CH_3COOH ✓</td><td>CH_3COOH ***OR*** HCl ***OR*** H_2O ✓</td></tr></table>	*Award M2 if only the by-product correspond to the reagent.*	**2**

(continued)

(Question 17 continued)

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

18.	**a**		$Mg(OH)_2(s) + 2HCl(aq) \rightarrow 2H_2O(l) + MgCl_2(aq)$ ***OR*** $Mg(OH)_2(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + 2H_2O(l)$ ✓		**1**
	b		$\frac{1.00}{58.33} = 0.0171$ ‹mol $Mg(OH)_2$› ✓ ‹$0.0171 \times 2 \times 36.46 =$› 1.25 ‹g› ✓	*Award **[2]** for correct final answer.*	**2**

(continued)

(Question 18 continued)

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

19.	**a**		**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 ✓	*Award 1 mark for example **and** corresponding treatment.* *Award **[1 max]** for the two types of waste.*	**2**

(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**