Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

CHEMISTRY **0620/42**

Paper 4 Theory (Extended) **February/March 2024**

MARK SCHEME

Maximum Mark : 80

Question	Answer	Marks	Guidance
			For equations: Unless stated, A multiples I state symbols
1a	coke	**1**	**I** graphite/diamond/coal/charcoal
1aii	provide heat	**1**	**A** Provide carbon dioxide / CO_2 **A** provide (thermal) energy / generate high temperature / increase the temperature **I** oxidation of C **I** Produce carbon monoxide / CO **I** equations **R** to reduce iron (oxide)
1bi	M1 rfm of Fe_2O_3 = 160 M2 mass of Fe = 2 x 56 = 112 and percentage Fe = 100 x 112/160 = 70.(0)%	**2**	**A** 2 marks for 70 / 1 mark for 35 **A** (2 x 56) + (3 x 16) for M1 if 160 is not seen but if evaluated must be correct An 'unspecified' 160 can be seen anywhere (but should not be contradicted) If M1 is not awarded **A** for M2 a correctly evaluated sum for Fe = 100 x **112**/ Mr greater than 112 even if it means doing the Mr calculation for them **I** SF/rounding beyond whole numbers **R** use of atomic numbers for M1 and M2
1bii	hematite	**1**	**A** haematite or heamatite or heematite **A** phonetically correct near miss versions eg hemetite, hemmatite Not '…ide' or '..ate'
1biii	by reduction of carbon dioxide	**1**	**A** Correct Equation **A** reaction of C/coke **with** CO_2 **A** incomplete combustion of C / equation **I** oxidation of carbon **I** 'redox'
1biv	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ M1 species M2 correct equation	**2**	**A** $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ **A** $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$
1bv	reduction	**1**	**I** redox **I** e gain/loss/equations showing e gain loss **I** oxidation number changes
1c	thermal decomposition	**1**	**I** 'decomposition' alone **I** 'endothermic'

Question	Answer	Marks	Guidance
di	M1 CaO is basic M2 SiO_2 is acidic	**2**	**A** CaO is an alkali for M1 **A** silicon oxide / silica / incorrect oxidation state of Si For 1 salvage mark: **A** CaO is acidic **and** SiO_2 is basic. **A** Metal oxides are basic **and** non-metal oxides are acidic (non specific) **A** CaO is a metal oxide **and** SiO_2 is a non-metal oxide **A** It is a reaction between a metal oxide **and** a non-metal oxide **I** it is a neutralisation **I** answer in term of proton gain / loss **I** Ca is a metal Si is a non-metal **I** "salt" e.g. calcium oxide is a basic salt would get M1
dii	M1 Silicon(IV) oxide M2 slag	**2**	**A** Silicon dioxide / **A** Silica **A** silicon(IV) dioxide **I** silicon oxide but **R** incorrect oxidation numbers **A** calcium silicate
ei	Aluminium is above carbon in the reactivity series or aluminium is more reactive than carbon	**1**	Answer needs to be reactivity based But **A** Temperature would need to be **too** high Assume 'it' is Al **I** Melting point comments **I** 'Al can't be reduced/displaced by C/CO' **I** Al is too reactive **I** Al more reactive than Fe **I** It's uneconomic
eii	electrolysis	**1**	**A** Hall-Heroult (process) **I** reduction/redox
fi	2,8	**1**	**A** 2 8 2/8 2:8 etc **A** $1s^2$ $2s^2$ $2p^6$ **I** diagrams
fii	M1 26p M2 23e	**2**	**A** salvage for M2 = M1 – 3
		19	

Question	Answer	Marks	Guidance
2a	fluor**ine**	**1**	**A** F_2 / F
2b	red-brown **and** liquid	**1**	**A** 'red' or 'brown'. **R** 'orange' and any other colour for the liquid **I** shades **I** comments about vapour
2c	M1 Ts M2 7 M2 must be linked to M1	**2**	**A** TS ('T' must be capital) **A** tennissine (be generous with spelling) **A** M2 if M1 is a period 7 element. **A** ECF for M2 if M1 is a **halogen** eg At = 6 I = 5 Br = 4 Cl = 3 F = 2
2di	M1 **pair** of electrons M2 electron(s) shared between **two** atoms	**2**	For pair **A** two **A** M1 for covalent bond**s** are pair**s** of electrons **R** M1 for 'one or more pairs of electrons' Shared = attracted and Atoms = nuclei For M2 **A** electrons between **two** atoms / **two** nuclei For M2 **R** ions / charged atoms / IMFs **I** strength of bonds **I** reference to non-metals eg electrons shared between two non-metal atoms gets M2 **A** 1 salvage mark for: electrons **shared** between **(**two**) atoms** / **nucle**i (2 is not needed but any other number loses the mark) **or** **(**two**) atoms / nuclei sharing** electrons (2 is not needed but any other number loses the mark)
2dii	Iod**ide /** Astat**ide** / Tenness**ide**	**1**	**A** I^- / At^- / Ts^- **I** Iodine ion **I** Iodied **R** 'iodine/iodide' **R** 'iodine/I^-' (hedging their bets) **R** any compound. Eg sodium iodide for iodide etc
2diii	brom**ine** is more reactive than iod**ine** / astat**ine** / tenness**ine**	**1**	Both halogens must be seen and correct relative reactivity applied ORA Halogen must match halogen of halide in 2dii For brom**ine**, **A** Br_2 / Br For iod**ine A** I_2 / I / Astat**ine** / At_2 / At / Tenness**ine /** Ts_2 / Ts Assume 'It' = bromine **I** unqualified group trends in reactivity **A** bromine / Br_2 / Br higher in reactivity (series) than iod**ine /** I_2 / I **A** Bromine is a stronger oxidising agent than iodine etc If Cl/F used in 2dii **A** Br **less** reactive than Cl/F as ECF

Question	Answer	Marks	Guidance
2e	M1 cobalt(II) chloride M2 anhydrous	 **2**	**A** $CoCl_2$ **I** lack of Roman numerals **R** incorrect Roman numerals M2 is stand alone
2f	M1 eight crosses in third shell of Ca M2 7 dots and 1 cross in third shell of both Cl M3 '2+' charge on Ca on correct answer line **and** '–' charge on both Cl ions on correct answer line	 **3**	**I** empty fourth shell of Ca **A** M2 as ECF if both Cl have 8 dots in 3rd and Ca has 8 dots in 3rd shell **A** 'Ca^{2+}' and 'Cl^{-}' as charges **R** M1 If e appear in Ca 4th shell and Cl 3rd shell (usually with transfer arrows)
2gi	lead(II) nitrate	 **1**	**A** correct formula but name takes precedence over a formula **I** lack of Roman numerals but **R** incorrect Roman numerals **A** (Lead) nitrate **A** (Lead) ethanoate/acetate
2gii	$Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2(s)$ M1 $PbCl_2$ as **only** product M2 $Pb^{2+} + 2Cl^{-}$ as **only** reactants M3 states	**3**	M1 **R** ionic charges on $PbCl_2$ eg $Pb^{2+}2Cl^{-}$ M1 **R** other products and product spectator ions / electrons for M1 **A** $2PbCl_2$ / $3PbCl_2$ etc as part of M1 **A** Pb^{+2} / Pb^{++} No ECF for incorrect lead(II)chloride formula eg Pb_2Cl **R** AQ / Aq / aQ for aq **A** M3 (states) for any +ve lead ion and any negative chloride ion and any lead chloride formula Eg $Pb^{+}(aq) + Cl^{2-}(aq) \rightarrow Pb_2Cl(s)$ As a special case: Max 2 marks for full equation: M1 correct equation (including correct formulae and balancing) Equation must 'work' ie soluble lead salt + soluble chloride (inc HCl here) – does not have to be the same reagent as 2gi M3 states (ie (aq) + (aq) → $PbCl_2(s)$ + (aq) **R** charges eg Na+Cl– etc in full equations If full equation is incorrect no M3 is awarded.

Question	Answer	Marks	Guidance
			If ionic equation does not balance award up to 2 marks eg $Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow 2PbCl_2(s)$ But correctly balanced multiples would get 3 marks eg $2Pb^{2+}(aq) + 4Cl^{-}(aq) \rightarrow 2PbCl_2(s)$
2giii	silver chloride	**1**	**A** Formula **A** silver (chloride) **I** Ag / Ag+ **A** Mercury(I) (chloride)
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Question	Answer	Marks	Guidance
3a	proton acceptor	**1**	**A** H^+ acceptor/hydrogen ion acceptor **A** 'receiver' etc for 'acceptor' **I** references to pH/indicators/reactions/alkalis/electron pair transfer/oxides etc
3b	a soluble base	**1**	**A** soluble proton acceptor or soluble any other term acceptable in 3a (doesn't have to be the one used in 3a) **A** soluble oxides or hydroxide of a metal **A** produces OH^- ions in (aqueous) solution **A** an aqueous base **I** 'alkalis are soluble' **I** pH references
3c	M1 blue M2 colourless	**2**	**I** shades
3di	M1 HNO_3 M2 lowest pH	**2**	**A** nitric acid **I** incorrect name provided it doesn't contradict the answer by naming one of the others M2 **I** It is most acidic (must use info in table) **I** it has a pH of (only) 1 **I** refence to acid strength
3dii	universal indicator	**1**	**A** 'UI'
3e	$(CH_3COOH) \rightleftharpoons CH_3COO^- + H^+$ M1 H^+ M2 CH_3COO^- M3 use of $\rightleftharpoons$	**3**	**I** additional reactants and products for M1 **R** multiples of H^+ eg $4H^+$ **A** $C_2H_3O_2^-$ **R** any third product for M2 **A** $\leftrightharpoons$ or $\leftrightarrows$ or $\rightleftarrows$ **I** '=' for '$\rightleftharpoons$' **A** Answers which show total equation on the answer line so CH_3COOH appears twice **A** up to 3 marks for $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$
3f	$H^+ + OH^- \rightarrow H_2O$	**1**	**R** full equation for formation of water from alkali + acid eg NaOH + CH_3COOH

Question	Answer	Marks	Guidance
3g	M1 mol of $Ca(OH)_2$ = 0.0150 x 20.0/1000 = 0.0003(00) / 3.00 x 10^{-4} M2 mol of HNO_3 = M1 x 2 = 3.00 x 10^{-4} x 2 = 0.0006 / 6.00 x 10^{-4} M3 concentration HNO_3 = M2 x 1000/25.0 = 6.00 x 10^{-4} x 1000/25.0 = 0.0240 (mol / dm^3) M4 M_r HNO_3 = 63 M5 concentration HNO_3 = M3 x 63 = 0.0240 x 63 = 1.51(2) (g / dm^3)	**5**	Mark M1, M2 and M3 Then M4/M5 **I** fractions once as answers for M1, M2 and M3 M4 can be seen anywhere in the answer unless contradicted in stated M_r of the M4 mark **A** M4 and M5 for (incorrect M3) x 63, even if 63 is left as 1 + 14 + (3 x 16) **R** M5 as a fraction, but **A** 'numerical' M5 (and M4) for correct 63 x fraction in M3 **A** ECF from M3 to M5 if incorrect M_r is **stated** (not simply left as a sum) **R** (for M4 and M5) if '24' as stated M_r **A** sig figs / incorrect rounding / truncation errors when awarding ECF **A** M4 and M5 if M5 is 63 x M3 If the 'correct' M_r of nitric acid is left as an unevaluated sum and **not** used to multiply M3, then no M4 can be awarded If an 'incorrect' M_r of nitric acid is left as an unevaluated sum and used to multiply M3, then no M4 or M5 can be awarded **A** truncation / rounding to 1 DP unless whole number. Ie 1.5 (if this is M3 x 63) **A** 5 marks for correct final answer if nothing else is seen.
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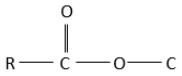
Question	Answer	Marks	Guidance
4ai	structural	**1**	**I** 'carboxylic acid' **A** Condensed structural formula **I** structured
4aii	CH_2O_2	**1**	**A** Any order **A** HCOOH = CH_2O_2 ie they have attempted working
4b	M1 ethyl methanoate M2 ester link M3 correct displayed formula of ethyl methanoate	**3**	M1 A ethyle /ethy / 'ethly' **A**: methonoate/methnoate **R**: methenoate/ methanote Must end in -oate  M2 is given for any ester linkage with all atoms and all bonds (R is of course 'H' but could be C for M2) **A** $–CH_2–CH_3$ **A** $–C_2H_5$ but ester link must be displayed **A** ECF for M3 if methyl ethanoate is named in M1 **A** M2 and M3 if seen as a product of an equation.
4ci	nothing can enter or leave	**1**	**A** just 'enter' or just 'leave' **A** alternatives such as no reactants **or** no products / particles / gases etc can escape **A** only heat/energy can be exchanged/transferred' **I** phrases which repeat the question eg 'fully enclosed reaction system' / 'closed environment' / 'sealed system' **I** comments with reference to 'air not entering/leaving' **I** External interactions
4cii	M1 The rate of forward reaction equals (the rate of the) reverse reaction M2 concentrations of reactants and products are constant	**2**	M1 **A** both reactions occur at the same rate **A** 'Reactants and products are formed at the same rate' **I** comments on making and breaking bonds **I** forward reaction = backward/reverse reaction (no rate) M2 **A** concentration(s) are constant/no change in concentration/ concentrations **stay** or **remain** the same **A** concentration(s) of *reactants* are constant **A** concentration(s) of *products* are constant **I** concentration of reactants and products **are** the same (could mean either constant or equal)

Question	Answer	Marks	Guidance
			A moles/amounts/masses as alternative to concentration **R** concentrations (of reactants and products) are equal **I** Closed system **A** no change in macroscopic properties
4ciii	M1 increases M2 decreases M3 decreases M4 no effect	**4**	**A** Synonyms or vertical arrows **I** equilibrium shifts
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Question	Answer	Marks	Guidance
5a	(but-1-ene) has lower relative molecular mass	1	**A** lowest for lower (must be comparative or superlative) **A** lower M_r / molar mass / relative formula mass / molecular mass / lighter molecules **R** (relative) atomic mass / lighter atoms / mass number **A** But-1-ene has Mr of 58 **and** butane has M_r of 60. **I** incorrect M_r **I** lower particle mass / lower mass / less dense / lighter gas / smaller molecules
5b	carbon dioxide **and** water	1	**A** name or correct formulae **R** incorrect name / formulae **A** steam / water vapour **A** CO_2 **and** H_2O as only products of attempt at an equation **I** heat/energy
5ci	photochemical	1	**A** Photodecomposition **A** close attempts eg. Photochemic **I** photochromic **I** UV reaction **I** substitution
5cii	to provide activation energy	1	**A** to **provide E to** break the **Cl-Cl** bond (must be the Cl-Cl bond, not just 'bonds') **A** To **provide E** to start/initiate reaction/to create radicals/to allow reaction to occur **A** To **provide E** to increase rate **I** 'provide E' alone **R** catalyst **R** 'heat' for 'energy' **A** to provide E to overcome E_a
5ciii	substitution	1	**I** photochemical **I** chlorination / halogenation / (free) radical **I** electrophilic/nucleophilic references
5civ	2	1	
5di	acid	1	**A** phosphoric **acid** or sulfuric **acid** as 'acid' **I** 'dilute' / conc' **A** H_3PO_4 / H_2SO_4 without term acid but **I** incorrect formulae if name is used. **R** Ni/V_2O_5/Fe/Pt etc **R** enzyme

Question	Answer	Marks	Guidance
5dii	M1 Displayed formula of butan-1-ol M2 Displayed formula of butan-2-ol M3 Butan-1-ol (as either name) M4 Butan-2-ol (above displayed formula of butan-2-ol)	**4**	Mark fully displayed formulae first. All atoms and all bonds are needed but see below **A** any order of fully displayed formulae. Name must match **fully** displayed formulae If any formula is not fully displayed (likely to be –O–H shown as –OH), mark any not fully displayed isomer first (no first mark). **A** ECF from first not fully displayed isomer if second isomer is not fully displayed and unambiguous structures of **both** C_4H_9OH isomers are seen For ECF to be applied for use of –OH to second structure, connectivity must be correct in both structures If structure is unambiguous in M1/M2 but not fully displayed **A** correct names for M3/M4 If no structure is seen in M1 and/or M2 **A** butan-1-ol and butan-2-ol as names If neither displayed formula is creditworthy **A** butan-1-ol and butan-2-ol as names in either order. **A** n-butyl alcohol / 1-butanol / 1-hydroxybutane for butan-1-ol **A** isobutyl alcohol / 2-butanol / 2-hydroxybutane for butan-2-ol
5ei	addition (polymerisation)	**1**	I additional
5eii	M1 chain of 6 C atoms joined by single bonds in a chain M2 three correctly placed C_2H_5 groups M3 Correct structure **and** continuation bonds	**3**	**I** side chains, incorrect CH and or CH_2 in C chain for M1 **I** valency of C for M1 ie A **6** C in a row bonded with single bonds M2 **A** $–C_2H_5$ as $–CH_2–CH_3$ or fully displayed **A** any possible arrangement (idio/ iso / syntactic etc) and be lenient on connectivity errors to C_2H_5 **I** brackets and/or 'n' / other numbers / other products Special cases If anything other than three repeat units, **A** up to two marks for M2 and M3 if structure is completely correct. One repeat unit of poly(but-1-ene) could get M2 and M3 Polybut-2-ene could score M1 and M3 if all C in chain have H and CH_3
		15	