Cambridge International Examinations
Cambridge Pre-U Certificate

CHEMISTRY **9791/02**

Paper 2 Part A Written **May/June 2017**

MARK SCHEME

Maximum Mark: 100

Published

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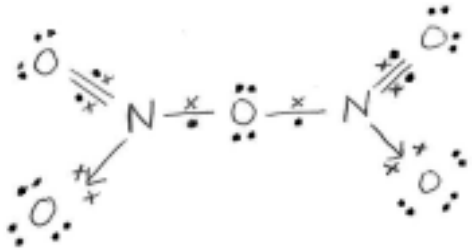
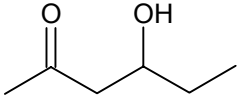
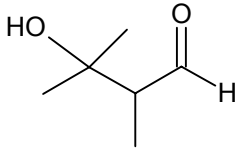
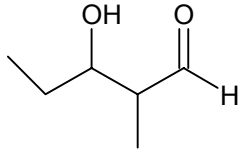
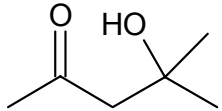
Question	Answer	Marks
1(a)(i)	3D diagram 	**1**
1(a)(ii)	Octahedral / octahedron AND 90°	**1**
1(a)(iii)	Electron pairs repel equally / move as far apart as possible (1) Six electron pairs / six bonds and no lone pair (1)	**2**
1(a)(iv)	(SF_6 is symmetrical so) all (bond) dipoles / partial charges cancel	**1**
1(b)	Amount of SF_6 = 10.0 / 146.1 = 0.0684 mol or using ratio of the two formula masses (1) Mass of Li = 8 × 0.0684 × 6.9 = 3.78 g or 3.8 g (1)	**2**
1(c)	Sulfur (increases) from 0 to +4 (SF_4) AND sulfur (decreases) from 0 to −2 (CuS) (1) Disproportionation because the oxidation number of sulfur (both) increases and decreases in the reaction OR sulfur is oxidised and reduced (1)	**2**
1(d)	$CH_3CHCl CH_2SF_5$ (1) $CH_3CH(SF_5)CH_2Cl$ (1)	**2**

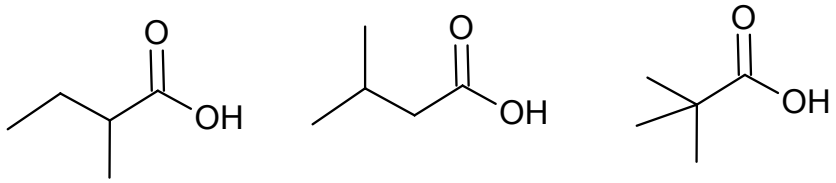
Question	Answer	Marks
2(a)	Strong / large amount of energy to break (nitrogen to nitrogen) triple bond	**1**
2(b)(i)	NH_2	**1**
2(b)(ii)	N_2H_4	**1**
2(c)(i)	When a (covalent) bond breaks and each atom gets one electron (from the bonding pair) OR bond breaking to form (two free) radicals	**1**
2(c)(ii)	NO is used in step 2 and regenerated / reformed in step 3	**1**
2(d)	Correct connectivity, i.e. 2Ns and 5Os with a central bridging O (1) Correct dative covalent N→O bond on each nitrogen, but only 1 per N atom (1) All remaining valence electrons correct. Lines and arrows are not required (1) 	**3**
2(e)	$-905.2 = -(4 \times -46.1) + (6 \times -241.8) + 4\Delta_f H^{\ominus}(NO)$ Stoichiometry correct (4, 6 and 4) in diagram or calculation OR correct cycle (1) All signs correct (1) $\Delta_f H^{\ominus}(NO) = +90.3\ kJ\ mol^{-1}$ (1)	**3**

Question	Answer	Marks
3(a)	Correct sketches for each property (1 mark each) Atomic radius decreasing from left to right (1) Electrical conductivity increasing from Na to A*l*, dropping to Si below Na, with remaining four elements below Si (1) Melting point increasing from Na to Si, dropping to P, increasing to S, decreasing to C*l* and again to Ar (1)	**3**
3(b)	NaC*l* giant **AND** SiCl_4 simple (molecular structure) (1) NaC*l* has strong forces of attraction between the ions / strong ionic bonding (1) SiCl_4 has weak van der Waals' / London / dispersion / IDID forces between the molecules (1)	**3**
3(c)	NaC*l* + H_2SO_4 → $NaHSO_4$ + HC*l* OR 2NaC*l* + H_2SO_4 → Na_2SO_4 + 2HC*l* (1) Misty / white / steamy AND gas / vapour / clouds / fumes (of HC*l*) (1) 2NaBr + 2H_2SO_4 → Br_2 + SO_2 + 2H_2O + Na_2SO_4 OR 2NaBr + 3H_2SO_4 → Br_2 + SO_2 + 2H_2O + 2$NaHSO_4$ OR 2HBr + H_2SO_4 → Br_2 + SO_2 + 2H_2O (1) Brown vapour / gas / fumes (1) 8NaI + 5H_2SO_4 → 4I_2 + H_2S + 4H_2O + 4Na_2SO_4 OR 8NaI + 9H_2SO_4 → 4I_2 + H_2S + 4H_2O + 8$NaHSO_4$ OR 8HI + H_2SO_4 → 4I_2 + H_2S + 4H_2O (1) Bad egg smell / dark grey solid forming / purple gas / vapour / yellow solid (1)	**6**
3(d)	SOCl_2 + H_2O → SO_2 + 2HC*l*	**1**
3(e)(i)	Neutralisation with / add any base or alkali (1) $CaCO_3$ + SO_2 → $CaSO_3$ + CO_2 OR $Ca(OH)_2$ + SO_2 → $CaSO_3$ + H_2O (1)	**2**
3(e)(ii)	Sulfur has a lone pair AND carbon does not have a lone pair	**1**
3(e)(iii)	Bond vibrations are excited	**1**

Question	Answer	Marks
4(a)(i)	H_{28}	**1**
4(a)(ii)	6	**1**
4(b)	Acidified / H^+ $K_2Cr_2O_7$ OR acidified / H^+ $KMnO_4$ OR Lucas test (1) THG stays orange / no change AND testosterone changes from orange to green OR THG stays purple / no change AND testosterone decolourises OR Lucas reagent goes cloudy rapidly with THG and slowly with testosterone (1) Ignore answers based on bromine water unless relative volume of solution needed (1 mark) starting with the same quantity of THG and testosterone (1 mark)	**2**
4(c)(i)	C=O made of one sigma and one π-bond (1) π-bond results from sideways overlap of two (adjacent) (2)p orbitals (1) (a correct labelled diagram can score both marks)	**2**
4(c)(ii)	C=C has no dipole (so cannot attract nucleophiles) / is an electron-rich bond AND C=O has a (permanent) dipole (1) due of the presence of the (highly) electronegative O, OR mention/labelling of δ^+C and δ^-O (1)	**2**
4(d)	π-bond (in C=O) breaks and a new C–H bond is formed (and O–H bond forms) (1) FGL moves down a level OR FGL moves from carbonyl to alcohol or 2 to 1 (1)	**2**
4(e)	H_3CCH_2MgBr OR H_3CCH_2MgI	**1**
4(f)(i)	Addition	**1**

Question	Answer	Marks
4(f)(ii)	$CH_3COCH_2CH(OH)CH_2CH_3$ (–one attacks –al) [attack as nucleophile] 	3
	$CH_3C(OH)(CH_3)CH(CH_3)CHO$ (–al attacks –one) 	
	$CH_3CH_2CH(OH)CH(CH_3)CHO$ (–al attacks –al) 	
	$CH_3COCH_2C(OH)(CH_3)CH_3$ (–one attacks –one) 	
	1 mark for each correct structure up to a maximum of 3	

Question	Answer	Marks
5(a)(i)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$ Allow order of $4s^2$ and $3d^{10}$ to be reversed	**1**
5(a)(ii)	$(76 \times 0.0991) + (78 \times 0.2352) + (80 \times 0.5640) + (82 \times 0.1017)$ (1) = 79.3 3 s.f. (1)	**2**
5(b)	Atomisation of $2 \times$ Na AND $1 \times$ Se (1) $2 \times$ 1st IE for 2Na, giving $2Na^+ + 2e^-$ (1) 1st and 2nd electron affinity of Se – either separately or combined with correct label (1) Note: Electrons must be balanced in the IE and EA steps Lattice enthalpy (1) Correct state symbols (1)	**5**
5(c)	Axes labelled: difference in electronegativity / ΔE_{neg} (y) AND average E_{neg} (x) (1) Metallic (bottom left), ionic (top), covalent (bottom right) corners labelled (1)	**2**

Question	Answer	Marks
6(a)(i)	One correct 3D isomer (3D around the chiral carbon) (1) Correct mirror image (1)	**2**
6(a)(ii)	Dimer structure with 2 correct H bonds (1) C=O and O–H dipoles (1) Linear O–H to H-bonds and lone pairs indicated on H-bonds (1)	**3**
6(b)(i)	Specify M^+ / molecular ion / highest m / z is 102 peak (so M_r 102) (1) 31.4 / 100 × 102 = 32.03 OR 102-32 = 70 so 5C(60) and 10H (10) (1)	**2**
6(b)(ii)	 2–methylbutanoic acid 3–methylbutanoic acid (2,2–) dimethyl-propanoic acid Each correct structure + name scores 1 mark If no correct structure + name, three correct names OR three correct structures scores 1 mark	**3**
6(b)(iii)	3-methylbutanoic acid (or identified from last part) (1) Peak at δ 180 C=O / COOH / CO (1) 2-methylbutanoic acid gives 5 peaks (1) Dimethyl propanoic acid gives 3 peaks (1)	**4**

Question	Answer	Marks
7(a)	Structure of 2–methylbut–1–ene shown	**1**
7(b)	Sulfuric acid is oxidising OR causes charring	**1**
7(c)	M_r(B) = 70 (1) n(B) = 12 g / 70 g mol^{-1} = 0.171 mol (1) n(A) = 0.171 mol / 0.85 = 0.202 mol (1) m(A) = 0.202 mol × 88 g mol^{-1} = 17.75 g (1) v(A) = 17.75 g / 0.81 g cm^{-3} = 21.9 cm^3 OR 22 cm^3 (1)	**5**
7(d)(i)	To reduce evaporation of the alkene (since the boiling point is not far above room temperature) / maximise yield / reduce fire hazard	**1**
7(d)(ii)	Gloves (for handling the conc. phosphoric acid)	**1**
7(d)(iii)	To dry the alkene (as some water distils over with it) OR remove water OR drying agent	**1**
7(d)(iv)	With a heating mantle / hot plate OR a beaker of hot water from the hot tap (or from a kettle) / (hot-)water bath	**1**
7(d)(v)	Propene / the alkene intermediate / it is a gas (at r.t.p.)	**1**
7(e)(i)	To reduce / eliminate the evaporation of bromine (which is toxic)	**1**
7(e)(ii)	Bromine only has low solubility in water / water has low solubility in bromine (1) Water is less dense than bromine (1)	**2**
7(e)(iii)	Liquid bromine reacts vigorously / too quickly / very exothermically with alkenes	**1**

Question	Answer	Marks
7(e)(iv)	Dibromoalkane product, **C**, dissolves in the upper / organic layer OR upper / organic layer is converted to **C** (1) Upper / organic layer becomes denser (with increasing amount of **C** dissolved) OR **C** is denser (than **B**) (1) When density of upper / organic layer exceeds 1 / (the density of) water / the lower layer, it sinks below the water layer (1)	**3**
7(f)(i)	Yellow OR straw OR orange OR brown	**1**
7(f)(ii)	To prevent decomposition (when heated) OR in order to recover the product by steam distillation	**1**
7(f)(iii)	Drying (with a drying agent / desiccant)	**1**