

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Level

MARK SCHEME for the May/June 2015 series

9701 CHEMISTRY

9701/42

Paper 4 (Structured Questions), maximum raw mark 100

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1 (a) fluorine: $1s^2 2s^2 2p^5$ [1]

sulfur: $1s^2 2s^2 2p^6 3s^2 3p^4$

(b) (i) $2HCl \longrightarrow H_2 + Cl_2$ [1]

(ii) bond energies: HF (562) is **stronger** than HCl (431) [1]
or F_2 (158) is **weaker** than Cl_2 (244)

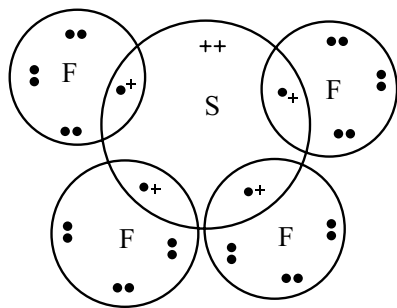
(c) *electronegativity:* [2]

The attraction by an atom/nucleus/element of the electrons in a bond or a shared pair or a molecule

bond polarity:

..is due to atoms/elements of **different** electronegativities at each end of a bond

(d) (i)



(ii) Yes, it will have a dipole moment, [3]
either because it has an uneven distribution of electrons *or* because it contains a lone pair

or the S–F dipoles don't cancel *or* molecule is not symmetrical *or* diagram of see-saw shape.

(allow an ecf for "no dipole" if their structure in (d)(i) has **no** lone pair)

(e) Sulfur can use its d-orbitals *or* has low-lying / accessible / available d-orbitals *or* can expand its octet. [1]

(allow reverse argument for oxygen; do NOT allow just "sulfur has d-orbitals")

(f) (i) Burning of **fossil** fuels *or* coal / oil / petrol / natural gas (NOT methane *or* hydrocarbons) *or* volcanoes *or* roasting / burning sulfide ores

(ii) Acid rain [2]

[Total: 11]

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2 (a) $A_r = 204 \times 0.019 + 206 \times 0.248 + 207$ [2]

$= 207.21$

(correct ans = [2])

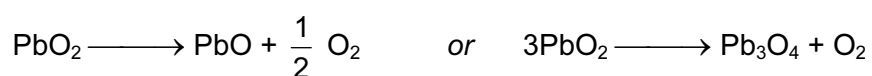
The **last** answer written by the candidate needs to be written with 2 d.p. to get the last mark.

(b) (i) Tin(II) oxide is more basic than tin(IV) oxide [1]
or tin(II) oxide is less acidic than tin (IV) oxide

(ii) e.g. $\text{SnO} + 2\text{HCl} \longrightarrow \text{SnCl}_2 + \text{H}_2\text{O}$ (or ionic or with H_2SO_4) [2]
 $\text{SnO}_2 + 2\text{NaOH} \longrightarrow \text{Na}_2\text{SnO}_3 + \text{H}_2\text{O}$ (or ionic or with KOH etc.)

(iii) SnO_2 stays the same (white) or is stable or no reaction [3]

PbO_2 changes colour (from brown/black to yellow/orange/red)



[Total: 8]

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3 (a) $^{33}\text{P}^-$ [2]

(b) Solubility decreases (from Mg to Ba *or* down the group) [4]

Both lattice energy / ΔH_{latt} and enthalpy change of hydration / ΔH_{hyd} are involved

enthalpy change of hydration **decreases more** than lattice energy

So enthalpy change of solution / ΔH_{sol} becomes more endothermic *or* more positive *or* less exothermic *or* less negative (NOT ΔH_{sol} decreases, or increases)

(c) precipitate / solid CaSO_4 would form [2]
 due to the **common ion effect** *or* K_{sp} is exceeded *or* the following equilibrium shifted over to the right
 $\text{Ca}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightleftharpoons \text{CaSO}_4(\text{s})$

(d) charge passed = $1.8 \times 40 \times 60$ (= 4320 C) [4]

$$n(\text{e}^-) = 4320 / 96500 \quad (= 4.477 \times 10^{-2} \text{ mol}) \text{ ecf}$$

$$n(\text{Cr}) = 0.776 / 52 \quad (= 1.492 \times 10^{-2} \text{ mol}) \text{ ecf}$$

$$n = 4.477 \times 10^{-2} / 1.492 \times 10^{-2} = 3.00 \quad (=3)$$

[Total: 12]

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- 4 (a) (i) a solution that resists / minimises a change in its pH *or helps* maintain its pH..... [2]
 (NOT any of: "maintains pH"; "keeps pH constant"; "no change in pH")
when small amounts of acid / H^+ or base / OH^- are added (**both** acid and base are needed)
- (ii) HCO_3^- reacts with H^+ ions as follows: [2]

$$HCO_3^- + H^+ \longrightarrow H_2CO_3 \text{ (or } H_2O + CO_2)$$
 and with OH^- ions thus:

$$HCO_3^- + OH^- \longrightarrow CO_3^{2-} + H_2O$$
 (the equation arrows can be equilibrium arrows, as long as HCO_3^- is on the left)
- (iii) ($pK_a = -\log(K_a) = 7.21$) [2]

$$pH = pK_a + \log([base]/[acid]) = 7.21 + \log(0.5/0.3)$$

$$= 7.43 \text{ (7.4)}$$
- (b) (i) $K_{sp} = [Ag^+]^3[PO_4^{3-}]$ and units: $mol^4 dm^{-12}$ [1]
- (ii) call $[PO_4^{3-}] = x$, then $[Ag^+] = 3x$, and $K_{sp} = 27x^4$ [3]

$$x = (K_{sp}/27)^{1/4} = (1.25 \times 10^{-20}/27)^{1/4} = 4.64 \times 10^{-6} mol dm^{-3}$$

$$[Ag^+] = 3x = 1.39 \times 10^{-5} (mol dm^{-3}) \quad (\text{allow } 1.4 \times 10^{-5})$$
- (c) $H_3PO_3 + 2Fe^{3+} + H_2O \longrightarrow H_3PO_4 + 2Fe^{2+} + 2H^+$ [2]

$$E_{cell} = 0.77 - (-0.28) = (+)1.05 V$$
 or $3H_3PO_3 + 3H_2O + 2Fe^{3+} \longrightarrow 3H_3PO_4 + 6H^+ + 2Fe$

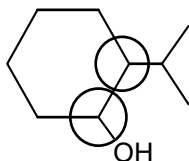
$$E_{cell} = -0.04 - (-0.28) = (+)0.24 V$$

[Total: 12]

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5 (a) (i) $\text{H}_2 + \text{Pt}$ or $\text{H}_2 + \text{Ni/Pd} + \text{heat/warm}$ or $50^\circ < T < 500^\circ\text{C}$ [1]

(ii)

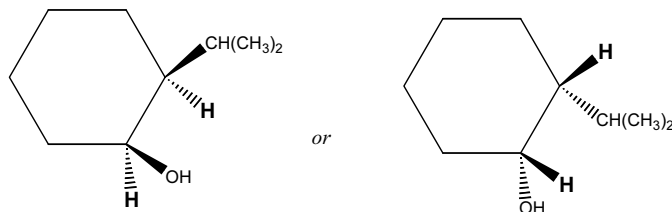


[1]

(iii) $2^2 = 4$

[1]

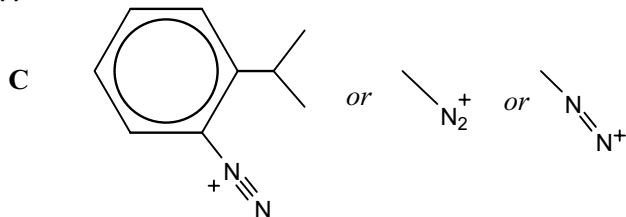
(iv)



2 Hs have to be on the **same side** of the ring. Allow $-\text{C}_3\text{H}_7$ or $-\text{R}$ for $-\text{CH}(\text{CH}_3)_2$ [1]

(b) (i)

[1]



(ii) step 1: **conc** $\text{HNO}_3 + \text{H}_2\text{SO}_4$ (@ $25^\circ\text{C} < T < 60^\circ\text{C}$ – see below) ("aq" negates) [4]

step 2: $\text{Sn/Fe} + \text{HCl}$

step 3: HNO_2 or $\text{NaNO}_2 + \text{HCl}$ (@ $T < 10^\circ\text{C}$ – see below)

both temperatures correct for steps 1 + 3 (temperature not required for step 2)

(inclusion of the word "heat" or "reflux" in step 3 negates the temperature mark)

(c)

[5]

HBr	no reaction	
Na		
NaOH(aq)		no reaction

[Total: 14]

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6 (a) There are three acceptable alternatives – follow each column down vertically:

(i) D is	RCOCl	$\text{RCOOCH}_2\text{CH}_3$	$\text{RCO}_2^- \text{NH}_4^+$
(ii) step 1	SOCl_2 (or PCl_3 or PCl_5)	ethanol (e.g.) + conc H_2SO_4	NH_3
(ii) step 2	NH_3 (NaOH negates this mark)		heat
(ii) step 3	LiAlH_4 (aq) negates (NOT NaBH_4 ; $\text{Sn} + \text{HCl}$ etc.)		

(b) (i) amine (other groups negate) [1]

(ii) phenol **and** carboxylic acid (**both** needed) [1]

(iii) [4]

compound	first functional group	second functional group
E	amide	alcohol
F	amine	carboxylic acid
G	amine	ester
H	amide	phenol

(iv) Mark this in the following way. For each structure of **E**, **F**, **G** and **H**: [4]

- check whether the structure fits the molecular formula $\text{C}_8\text{H}_9\text{NO}_2$, i.e. that it has: **one** nitrogen, **two** oxygens and **eight** carbons.
- check that it contains the two groups that the candidate's answers to part (ii) says it contains.

[Total: 13]

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- 7 (a) L – it is the only compound that is an amino acid *or* can **form** (NOT *contain*) [1]
 –NH–CO– / amide / peptide linkages / bonds
or
 it contains an N atom / NH₂ group / CO₂H group
- (b) mark both parts of this together – max [4] from the following six points [4]
 M1 mRNA is complementary to *or* a copy of (a portion of) DNA
 M2 mRNA encodes the sequence of amino acids in proteins *or* each of its codons (base triplets) codes for one amino acid
 M3 mRNA binds to / associates with the ribosome
 M4 tRNAs are **specific** to their amino acids
 M5 tRNA contains an **anticodon** *or* bonds to the codon / mRNA through base pairing *or* **translates** the RNA code into the amino acid sequence
 M6 tRNA carries the amino acid to the ribosome / mRNA
- (c) max [3] from the following six points. [3]
 M1 the pH of that area of the protein would change
 M2 protein becomes less hydrophilic / soluble *or* more hydrophobic
 M3 fewer hydrogen bonds *or* more van der Waals' (id–id) forces
 M4 fewer ionic bonds form
 M5 the tertiary structure / folding / (3D) shape (of the protein) would change
 M6 the active site would be different / less efficient

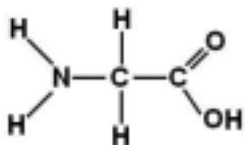
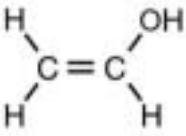
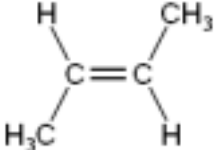
[Total: 8]

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- 8 (a) (i) The **nucleus/proton** of a hydrogen atom has **spin** [1]
- (ii) Hydrogen doesn't have enough electrons/electron density [1]
- (iii) S/sulfur – it has the greatest number of electrons *or* highest electron density [1]
- (b) (i) 12 protons (=9+2+1) [1]
- (ii) The group responsible for this peak is –OH (allow NH) [2]
The D in D₂O **exchanges** with the H in –OH *or* H is **replaced** by D
or "–OH → –OD",
- (iii) The adjacent carbon atom has no hydrogen atoms bonded to it [1]
- (iv) Methyl/CH₃ group [1]
- (v) P is (CH₃)₃C–CH₂OH [1]
- (c) (i) $n = \frac{100 \times (M+1)}{1.1 \times M} = \frac{100 \times 0.5}{1.1 \times 9.3} = 50/10.23$ [1]
= 4.89 hence **5** carbons
- (ii) (Ratio of ⁷⁹Br:⁸¹Br is 1 : 1), [1]
hence ratio of M : M+2 : M+4 is **1 : 2 : 1**
- (iii) Molecular formula of **R** is C₅H₁₀Br₂ [1]

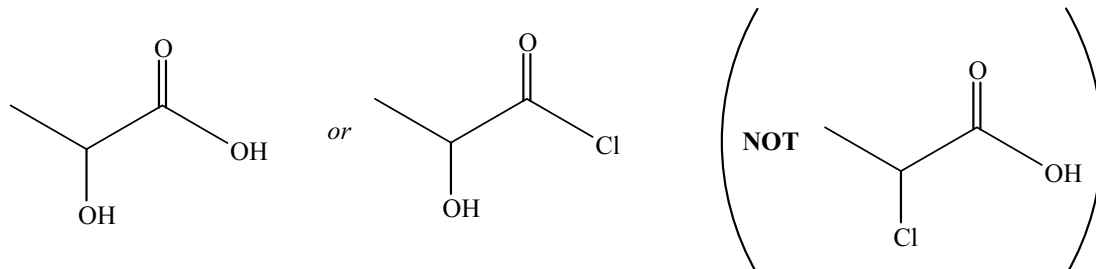
[Total: 12]

9 (a) [3]

monomer	addition	condensation	both
		✓	
	✓		
	✓		

(b) polythene is non-polar *or* its bonds are non-polar
so not (easily) **hydrolysed** [2]

(c) (i) [1]



(Allow displayed, skeletal, part-skeletal, structural etc.)

(ii) The **ester** (or –COO–) linkage/bond is hydrolysed *or* reacts with water [1]

(d) Polythene has (weak) van der Waals' (*or* id–id) forces [3]
 PVC has **stronger** van der Waals' forces *or* additional dipole forces
 Nylon has (strong) hydrogen bonding

[Total: 10]