

**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)

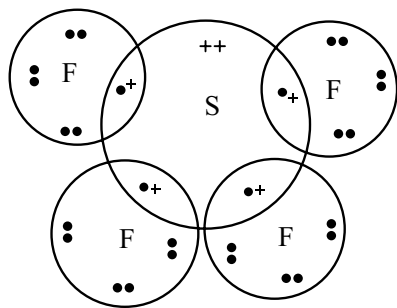
(c) *electronegativity*: [2]

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])

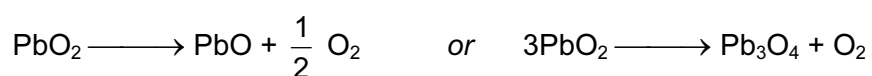
The **last** answer written by the candidate needs to be written with 2 d.p. to get the last mark.

(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  $\text{H}_2\text{SO}_4$ ) [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)  $\text{SnO}_2$  stays the same (white) or is stable or no reaction [3]

$\text{PbO}_2$  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 /  $\Delta H_{\text{latt}}$  and enthalpy change of hydration /  $\Delta H_{\text{hyd}}$  are involved

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

So enthalpy change of solution /  $\Delta H_{\text{sol}}$  becomes more endothermic or more positive or less exothermic or less negative (NOT  $\Delta H_{\text{sol}}$  decreases, or increases)

(c) precipitate/solid  $\text{CaSO}_4$  would form [2]  
 due to the **common ion effect** or  $K_{\text{sp}}$  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]

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

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

$n$  =  $4.477 \times 10^{-2} / 1.492 \times 10^{-2} = 3.00$  (=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<sup>+</sup> or base/OH<sup>-</sup> are added (**both** acid and base are needed)
- (ii) HCO<sub>3</sub><sup>-</sup> reacts with H<sup>+</sup> ions as follows: [2]  

$$\text{HCO}_3^- + \text{H}^+ \longrightarrow \text{H}_2\text{CO}_3 \text{ (or } \text{H}_2\text{O} + \text{CO}_2\text{)}$$
 and with OH<sup>-</sup> ions thus:  

$$\text{HCO}_3^- + \text{OH}^- \longrightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$$
 (the equation arrows can be equilibrium arrows, as long as HCO<sub>3</sub><sup>-</sup> is on the left)
- (iii) (pK<sub>a</sub> = -log(K<sub>a</sub>) = 7.21) [2]  

$$\text{pH} = \text{pK}_a + \log([\text{base}]/[\text{acid}]) = 7.21 + \log(0.5/0.3)$$

$$= \mathbf{7.43 \text{ (7.4)}}$$
- (b) (i) K<sub>sp</sub> = [Ag<sup>+</sup>]<sup>3</sup>[PO<sub>4</sub><sup>3-</sup>] and units: mol<sup>4</sup>dm<sup>-12</sup> [1]
- (ii) call [PO<sub>4</sub><sup>3-</sup>] = x, then [Ag<sup>+</sup>] = 3x, and K<sub>sp</sub> = 27x<sup>4</sup> [3]  

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

$$[\text{Ag}^+] = 3x = \mathbf{1.39 \times 10^{-5} \text{ (mol dm}^{-3}\text{)}} \quad (\text{allow } \mathbf{1.4 \times 10^{-5}})$$
- (c) H<sub>3</sub>PO<sub>3</sub> + 2Fe<sup>3+</sup> + H<sub>2</sub>O  $\longrightarrow$  H<sub>3</sub>PO<sub>4</sub> + 2Fe<sup>2+</sup> + 2H<sup>+</sup> [2]  

$$E_{\text{cell}} = 0.77 - (-0.28) = \mathbf{(+1.05 \text{ V}}$$
 or 3H<sub>3</sub>PO<sub>3</sub> + 3H<sub>2</sub>O + 2Fe<sup>3+</sup>  $\longrightarrow$  3H<sub>3</sub>PO<sub>4</sub> + 6H<sup>+</sup> + 2Fe  

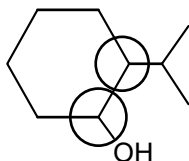
$$E_{\text{cell}} = -0.04 - (-0.28) = \mathbf{(+0.24 \text{ V}}$$

[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)

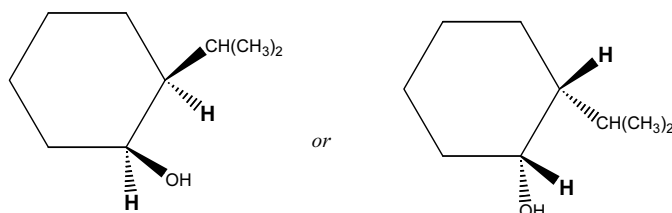


[1]

(iii)  $2^2 = 4$

[1]

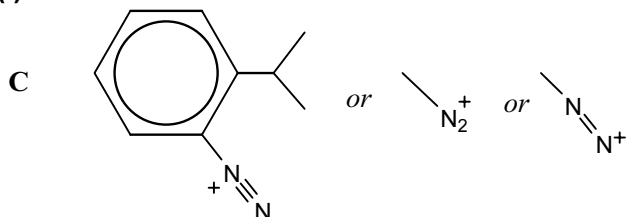
(iv)



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:  $\text{HNO}_2$  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	$\text{RCOCl}$	$\text{RCOOCH}_2\text{CH}_3$	$\text{RCO}_2^- \text{NH}_4^+$
(ii) step 1	$\text{SOCl}_2$ (or $\text{PCl}_3$ or $\text{PCl}_5$ )	ethanol (e.g.) + conc $\text{H}_2\text{SO}_4$	$\text{NH}_3$
(ii) step 2	$\text{NH}_3$ (NaOH negates this mark)	heat	
(ii) step 3	$\text{LiAlH}_4$ (aq) negates (NOT $\text{NaBH}_4$ ; $\text{Sn} + \text{HCl}$ 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	<b>amide</b>	<b>alcohol</b>
F	<b>amine</b>	<b>carboxylic acid</b>
G	<b>amine</b>	<b>ester</b>
H	<b>amide</b>	<b>phenol</b>

(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 / NH<sub>2</sub> group / CO<sub>2</sub>H 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]

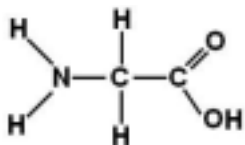
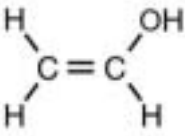
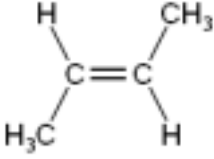


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- 8 (a) (i) The **nucleus/proton** of a hydrogen atom has **spin** [1]
- (ii) Hydrogen doesn't have enough electrons/electron density [1]
- (iii) S/sulfur – it has the greatest number of electrons *or* highest electron density [1]
- (b) (i) 12 protons (=9+2+1) [1]
- (ii) The group responsible for this peak is –OH (allow NH) [2]  
The D in D<sub>2</sub>O **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/CH<sub>3</sub> group [1]
- (v) P is (CH<sub>3</sub>)<sub>3</sub>C–CH<sub>2</sub>OH [1]
- (c) (i) 
$$n = \frac{100 \times (M+1)}{1.1 \times M} = \frac{100 \times 0.5}{1.1 \times 9.3} = 50/10.23$$
  
= 4.89 hence **5** carbons [1]
- (ii) (Ratio of <sup>79</sup>Br:<sup>81</sup>Br is 1 : 1), [1]  
hence ratio of M : M+2 : M+4 is **1 : 2 : 1**
- (iii) Molecular formula of **R** is C<sub>5</sub>H<sub>10</sub>Br<sub>2</sub> [1]

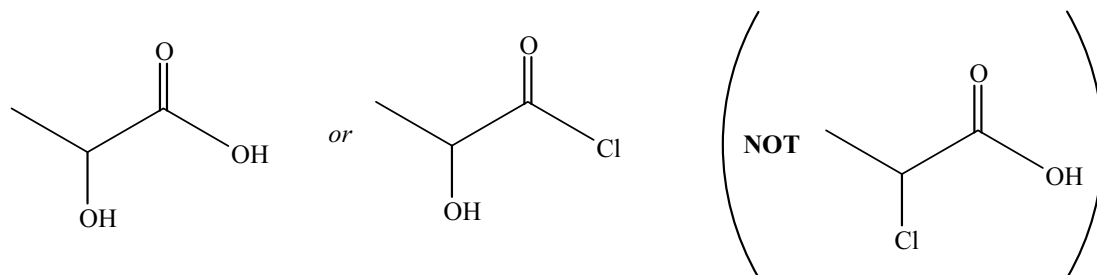
[Total: 12]

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]