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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CAMBRIDGE
International Examinations

1 **(a)** fluorine: $1s^22s^22p^5$ **[1]**

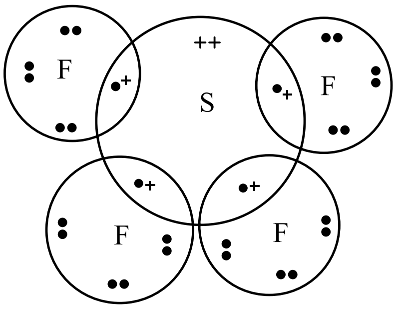
sulfur: $1s^22s^22p^63s^23p^4$

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

(ii) bond energies: HF (562) is **stronger** than HC*l* (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]

2 **(a)** A_r = 204 × 0.019 + 206 × 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. $SnO + 2HCl \longrightarrow SnCl_2$ + H2O(*or* ionic *or* with H_2SO_4) **[2]**

$SnO_2 + 2NaOH \longrightarrow Na_2SnO_3 + H_2O$ (*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)

$PbO_2 \longrightarrow PbO + \frac{1}{2} O_2$ *or* $3PbO_2 \longrightarrow Pb_3O_4 + O_2$

[Total: 8]

3 **(a)** $^{33}P^{-}$ **[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 $Ca^{2+(}aq) + SO4^{2-}(aq) \rightleftharpoons CaSO_4(s)$

(d) **[4]**

charge passed	$= 1.8 \times 40 \times 60$	(= 4320 C)
$n(e^-)$	= 4320 / 96500	$(= 4.477 \times 10^{-2}$ mol) ecf
n(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]

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]**

$$HCO3^- + H^+ \longrightarrow H_2CO_3 \ (\textit{or}\ H_2O + CO_2)$$

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 (7.4)**

(b) (i) $K_{sp} = [Ag^+]^3[PO_4^{3-}]$ **and** units: mol^4dm^{-12} **[1]**

(ii) call $[PO_4^{3-}] = x$, then $[Ag^+] = 3x$, and $K_{sp} = 27x^4$ **[3]**

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

$[Ag^+] = 3x =$ $\mathbf{1.39 \times 10^{-5}}$ ($mol\ dm^{-3}$) (allow $\mathbf{1.4} \times 10^{-5}$)

(c) $H_3PO_3 + 2Fe^{3+} + H_2O \longrightarrow H_3PO_4 + 2Fe^{2+} + 2H^+$ **[2]**

$E^\ominus_{cell} = 0.77 –(–0.28) = (+)$**1.05** V

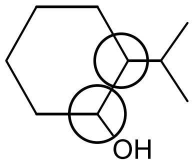
or $3H_3PO_3 + 3H_2O + 2Fe^{3+} \longrightarrow 3H_3PO_4 + 6H^+ + 2Fe$

$E^\ominus_{cell} = –0.04 –(–0.28) = (+)$**0.24** V

[Total: 12]

5 (a) (i) H_2 + Pt *or* H_2 + Ni / Pd + heat / warm *or* $50^o < T < 500\,^oC$ **[1]**

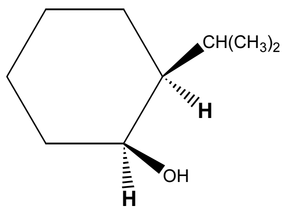
(ii)



[1]

(iii) 2^2 = **4** **[1]**

(iv)



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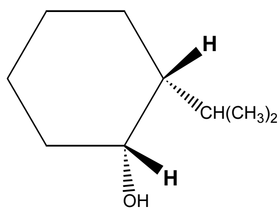
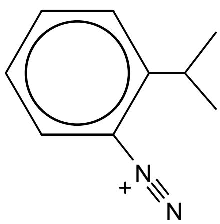


2 Hs have to be on the **same side** of the ring. Allow $–C_3H_7$ *or* –R for $–CH(CH_3)_2$ **[1]**

(b) (i) **[1]**

C



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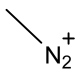

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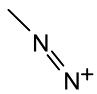
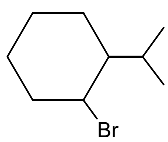
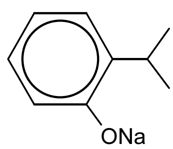
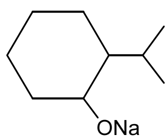
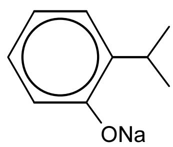


(ii) step 1: **conc** HNO_3 + H_2SO_4 (@ $25\,^oC < T < 60\,^oC$ – see below) ("aq" negates) **[4]**
step 2: Sn / Fe + HC*l*
step 3: HNO_2 *or* $NaNO_2$ + HC*l* (@ T< $10\,^oC$ – see below)
both temperatures correct for steps 1 + 3 (temperature not required for step 2)
(inclusion of the word "heat" or "reflux" in step 3 negates the temperature mark)

(c) **[5]**

HBr	no reaction	
Na		
NaOH(aq)		no reaction

[Total: 14]

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

(i) D is	$RCOCl$	$RCOOCH_2CH_3$	$RCO_2^- NH_4^+$
(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 $NaBH_4$; Sn + 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 $C_8H_9NO_2$, 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]

7 **(a)** **L** – it is the only compound that is an amino acid *or* can **form** (NOT *contain*) –NH–CO– / amide / peptide linkages / bonds **[1]**
or
it contains an N atom / NH_2 group / CO_2H 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]

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_2O **exchanges** with the H in –OH *or* H is **replaced** by D
or "–OH $\rightarrow$ –OD",

(iii) The adjacent carbon atom has no hydrogen atoms bonded to it **[1]**

(iv) Methyl / CH_3 group **[1]**

(v) P is $(CH_3)_3C–CH_2OH$ **[1]**

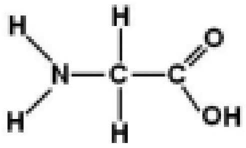
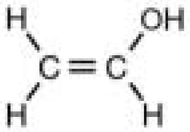
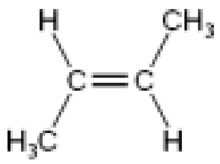
(c) **(i)** $n = \dfrac{100 \times (M+1)}{1.1 \times M} = \dfrac{100 \times 0.5}{1.1 \times 9.3} = 50/10.23$ **[1]**
= 4.89 hence **5** carbons

(ii) (Ratio of ^{79}Br:^{81}Br is 1 : 1), **[1]**
hence ratio of M : M+2 : M+4 is **1 : 2 : 1**

(iii) Molecular formula of **R** is $C_5H_{10}Br_2$ **[1]**

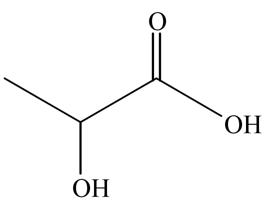
[Total: 12]

9 (a) **[3]**

monomer	addition	condensation	both
		✓	
	✓		
	✓		

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

(c) (i) **[1]**



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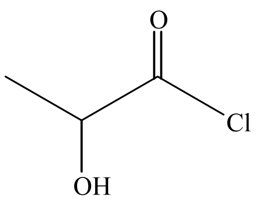
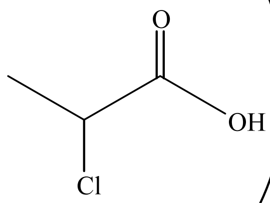


(**NOT**



)

(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]