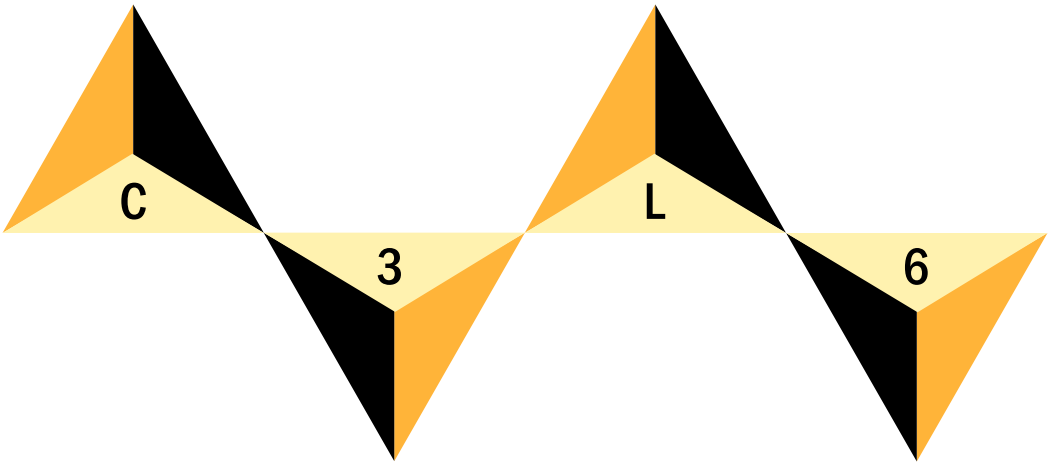


Cambridge Chemistry Challenge Lower 6th

June 2012

Marking scheme for teachers

(please also read the additional instructions)

	p2	p3	p4	p5	p6	p7	p8	Total
mark	8	9	10	3	5	11	14	60

leave blank

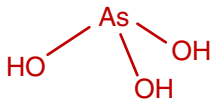
1(a) **(i) oxidation state of As**

+3 (or 3) ✓ 1

(ii) equation for production of As_2O_3

$$2FeAsS + 5O_2 \longrightarrow Fe_2O_3 + As_2O_3 + 2SO_2$$ ✓ 1

(b) (i) Structure of H_3AsO_3 **geometry around As:**



✓

(give a mark if planar but correct bonding)

pyramidal ✓

[accept a bond angle between 90° and 108°] 2

(ii) Equation for formation of H_3AsO_3:

$$As_2O_3 + 3H_2O \longrightarrow 2H_3AsO_3$$ ✓ 1

(iii) Concentration of H_3AsO_3:

RMM of As_2O_3 = (2 × 74.92) + (3 ×16.00) = 197.84

number of moles of As_2O_3 in 1 dm^3 = 20.6 / 197.84 = 0.104 ✓

from equation, 1 mol of oxide forms 2 mol acid 2

so concentration of acid = 0.208 mol dm^{-3} ✓

(c) (i) Mass of As_2O_3 in 100 cm^3:

20.6 g × 10^{-30} in 1 dm^3

∴ mass in 100 cm^3 = 2.06 × 10^{-30} g ✓ 1

[note this is much less than the mass of a single proton so there are no molecules of As_2O_3 in the glass]

Page total 8

1

leave blank

1(c) **(ii) volume needed for a fatal arsenic dose:**

2.06×10^{-29} g of As_2O_3 in 1 dm^3

so 0.1 g contained in $(0.1 / 2.06 \times 10^{-29})$ dm^3

$= 4.854 \times 10^{27}$ dm^3

$= 4.854 \times 10^{24}$ m^3 ✓

answer expressed as a fraction of the Earth's volume:

Volume of Earth = 1.08×10^{12} km^3

$= 1.08 \times 10^{12} \times 10^9$ $m^3 = 1.08 \times 10^{21}$ m^3

so volume needed is $(4.854 \times 10^{24} / 1.08 \times 10^{21})$ times the Earth

= 4500 times the volume of the Earth. ✓ ✓

[2 marks if all correct; 1 mark if a factor of 1000 out]

3

(iii) number of bottles to contain one atom:

2.06×10^{-29} g of As_2O_3 in 1 dm^3

∴ number of atoms of As in 1 dm^3

$= N_A \times (2.06 \times 10^{-29} \times 2) / 197.84$

$= 1.254 \times 10^{-7}$ ✓

volume required for 1 atom = $1 / 1.254 \times 10^{-7}$ dm^3

$= 7.97 \times 10^6$ $dm^3 = 7.97 \times 10^9$ cm^3 ✓

∴ number of bottles needed

$= 7.97 \times 10^9 / 28 = 285$ million ✓

3

1(d) **concentrations of HCl in mol dm^{-3}**

(i) D2 10^{-2} **(ii) D4** 10^{-4} **(iii) D6** 10^{-6}

(iv) D8 10^{-8} **(v) D10** 10^{-10}

[3 marks if all correct; −1 for each wrong answer down to zero]

3

Page total 9

leave blank

1(e) **(i) pH of pure water:** 7 ✓

[H^+] for pure water: 10^{-7} mol dm^{-3} ✓ 2

(ii) pH of solutions:

stock solution: pH = 0.0 ✓½ **D2 pH =** 2.0 ✓½

D4 pH = 4.0 ✓½ **D6 pH =** 6.0 ✓½ 4

D8 pH = 7.0 ✓ **D10 pH =** 7.0 ✓

[note the acid solution cannot become alkaline on diluting with water !]

(f) concentration of conc. HCl

RMM of HCl = 1.008 + 35.45 = 36.458

38 g = 38 / 36.5 mol in 100 g of solution

100 g of solution = 100 / 1.2 cm^3 ✓

∴ mols of HCl in 1 dm^3 =

(38 / 36.5) × (1.2 / 100) × 1000 = 12.5 ✓✓ 3

concentration = 12.5 mol dm^{-3}

[3 marks if correct final answer; partial marks for any key steps]

pH of conc. HCl

$-\log_{10}(12.5) = -1.1$ ✓ 1

Page total 10

leave blank

1(g) **concentration of pure water:**

RMM of H_2O = (2 × 1.008) + 16.00 = 18.016

1 dm^3 water ≡ 1.0 kg = 1000 / 18.016 mol

concentration = 55.5 mol dm^{-3} ✓

1

(h) **mass of acid:**

$[H^+] = 10^{18}$ mol dm^{-3}

so 1 dm^3 has a mass of 10^{18} × 1 g ✓

5 cm^3 has a mass of

$(10^{18} / 1000) \times 5$ g $= 5 \times 10^{15}$ g ✓

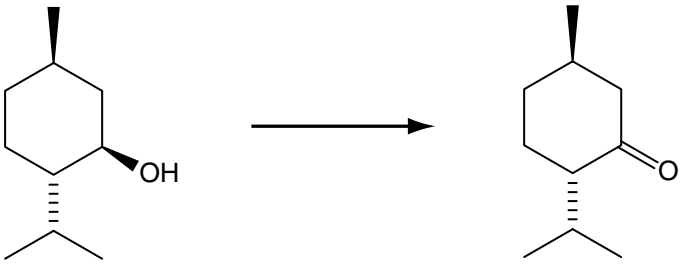
2

[Note this is more dense than a neutron star which essentially consists of touching nucleons. An additional idea might be to calculate the density of a single proton.]

Page total 3

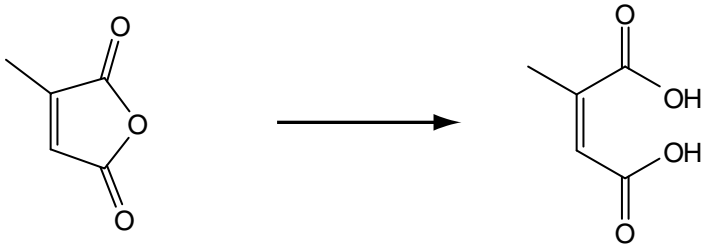
2 (a) *[half mark per answer]*

(i)



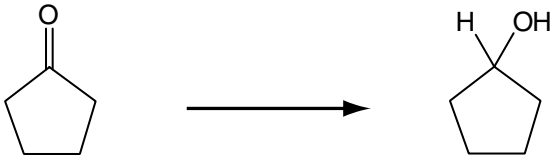
ox.	red.	hyd.
✓		

(ii)



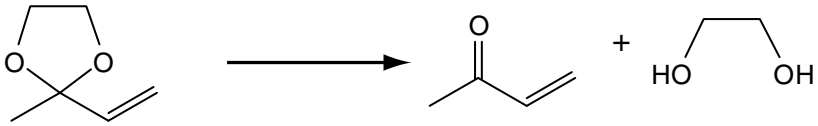
ox.	red.	hyd.
		✓

(iii)



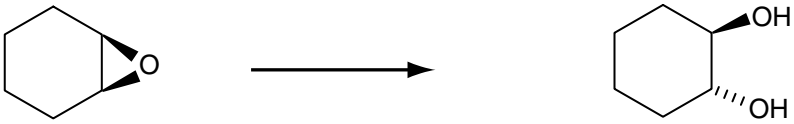
ox.	red.	hyd.
	✓	

(iv)



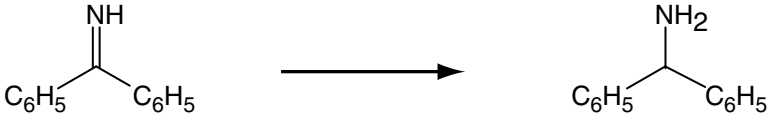
ox.	red.	hyd.
		✓

(v)



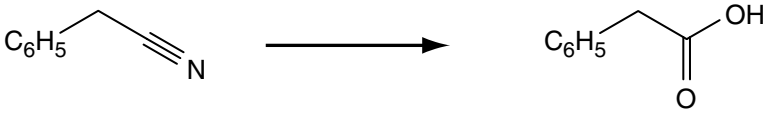
ox.	red.	hyd.
		✓

(vi)



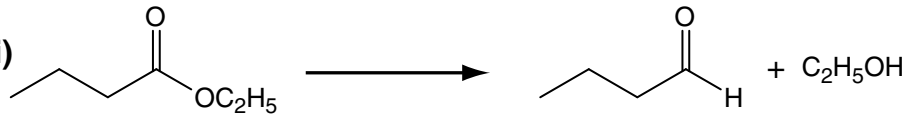
ox.	red.	hyd.
	✓	

(vii)



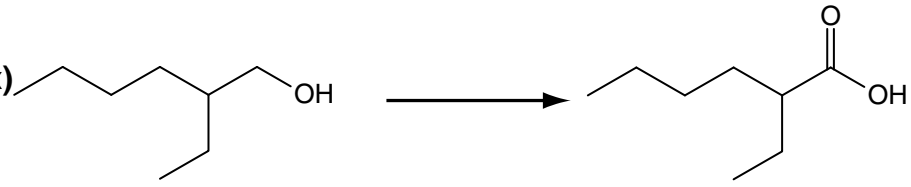
ox.	red.	hyd.
		✓

(viii)



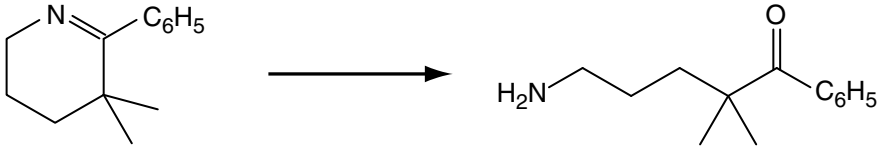
ox.	red.	hyd.
	✓	

(ix)



ox.	red.	hyd.
✓		

(x)



ox.	red.	hyd.
		✓

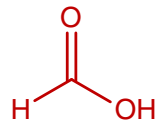
Page total 5

leave blank

2(b)

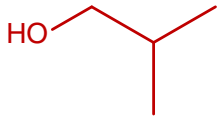
(i)

A (46)



✓

B (74)

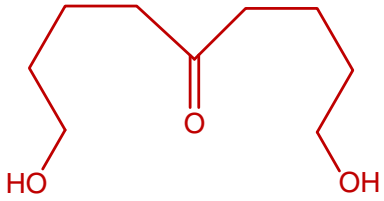


✓

2

(ii)

C (174)

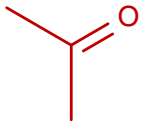


✓

1

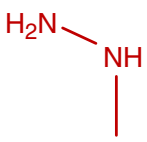
(iii)

D (58)



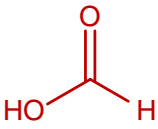
✓

E (46)



✓

F (46)



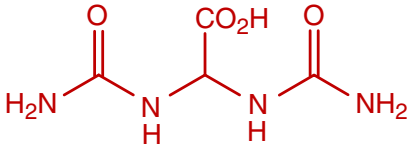
✓

[answers can be either way round]

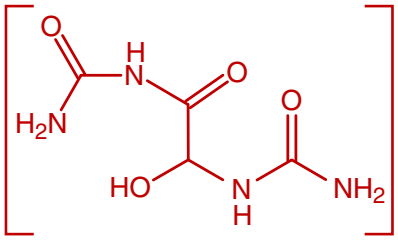
3

(iv)

G (176)

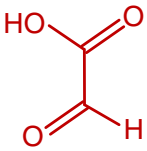


✓



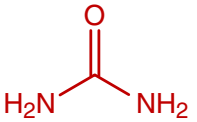
[allow this alternative]

H (74)



✓

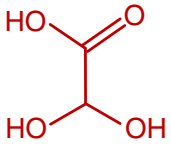
J (60)



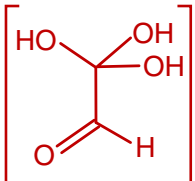
✓

5

K (92)

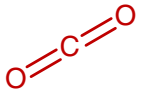


✓



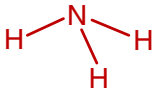
[allow this alternative]

L (44)



✓½

M (17)



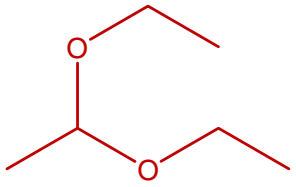
✓½

Page total 11

leave blank

2(c)

R



✓ ✓

2

S

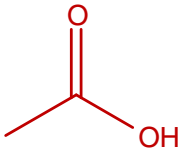
✓

T

✓

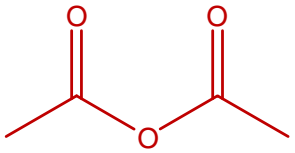
2

U



✓

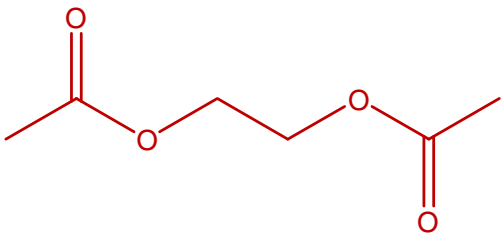
V



✓

2

W



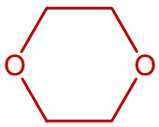
✓ ✓

2

X

✓ ✓

Y



✓ ✓

4

Z

✓ ✓

2

Page total 14