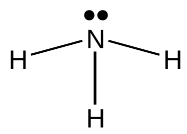
Olympiad 2001 - Round 1 answers

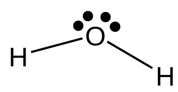
1. This question is about shapes of molecules

a) (1 mark for each correct shape)



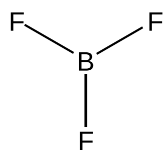
~107 ° (±1) (pyramidal)

b)



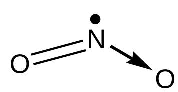
~104.5 ° (±1) (bent)

c)



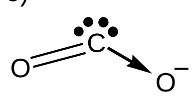
120 ° (trigonal planar)

d)



134 ° (allow 140 ° ±20)°

e)



110 ° ± 5 ° (bent)

Total 5

2. This question is about lattice enthalpies

i) FeO -(416 + 759 + 1561 + 249 + 657) + (-278) = **-3920 kJ mol^{-1}** (1)
CaO -(178 + 590 + 1145 + 249 + 657) + (-635) = **-3454 kJ mol^{-1}** (1)
(1 mark for each correct answer – must include units)

ii) **iron(II) oxide** (FeO) (1)

iii) -(-278) + (-635) = **-357 kJ mol^{-1}** (1)

iv) Calcium is too expensive, difficult to separate products, very violent reaction (any one reason accepted) (1)

v) A balance between I.E and lattice enthalpy (1)

Total 6

3. This question is about superconductors

i) Ratio 1:2:3:7 i.e. **$YBa_2Cu_3O_7$** (1 mark for correct method or very nearly correct answer, 2 marks for fully correct)

ii) oxidation state 14-(3+4)/3 = 7/3 Cu = **2.33** (1)

iii) 84.2/666.19 = x/658.19. x = **83.19 mg** (1 mark for masses(± 0.1 for variation in RAMs) + 1 mark for answer)

Total 5

4. This question is about Iodine Number

(i) By keeping the mixture of oil and iodine monochloride in the dark, free radical substitution of alkyl groups is prevented. (1)

(ii) $ICl(aq) + KI(aq) \rightarrow KCl(aq) + I_2(aq)$ (1 mark – must give full equation and not ionic equation – do not penalise for incorrect state symbols in this question)

(iii) 0.00400 moles (1)

(iv) 0.00200 moles of unreacted iodine monochloride (1)

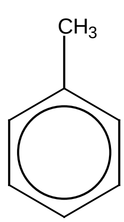
(v) 0.000500 moles (1)

(vi) 100 (1)

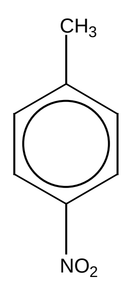
(–1 mark for incorrect sig figs in iii), iv) and v) **Total 6**

5. This question is about organic compounds

A



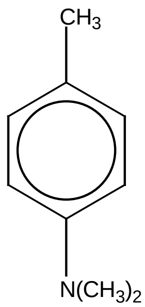
B



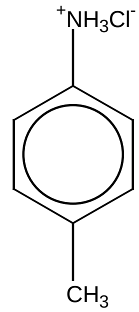
(Both A and B correct for 1 mark)

C-G (1 mark for each correct answer):

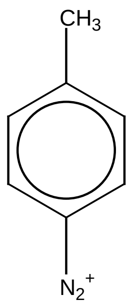
C



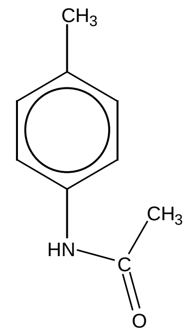
D



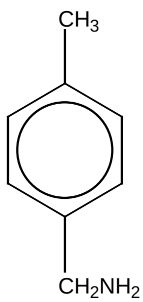
E



F



G



Total 6

6. This question is about metal nitrates

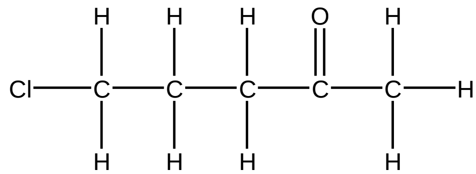
a)	$NaNO_{3(s)} \rightarrow NaNO_{2(s)} + ½\ O_{2(g)}$	(1)
	$Mg(NO_3)_{2(s)} \rightarrow MgO_{(s)} + 2NO_{2(g)} + ½\ O_{2(g)}$	(1)
b)	$2MnO_4^-{}_{(aq)} + 6H^+{}_{(aq)} + 5NO_2^-{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5NO_3^-{}_{(aq)} + 3H_2O_{(l)}$	(1)
c)	$2MnO_4^-{}_{(aq)} + 5(COO)_2^{2-}{}_{(aq)} + 16H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}$	(1)
d)	$NaNO_3$ = 4.25g $Mg(NO_3)_2$ = 11.1g	(2)
e)	1 : 2.4 (5:12) O_2:NO_2	(1)

Total 7

7. This question is about the identification of unknown organic compounds

(1 mark each correct compound – no follow on marks – take of ½ a mark for each answer where the student has NOT given DISPLAYED formula)

A =



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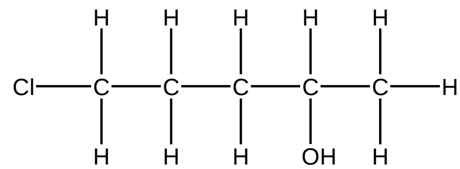
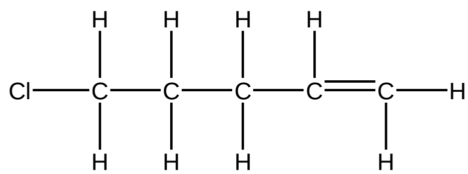
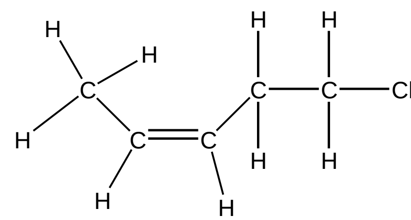


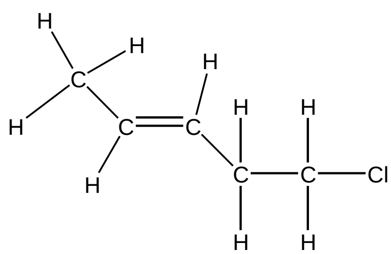
C =



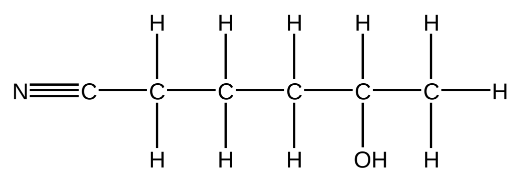
D =



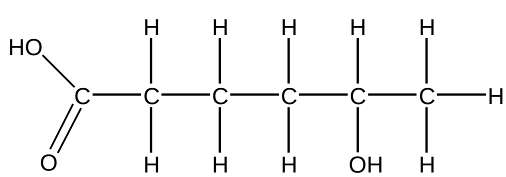
E =



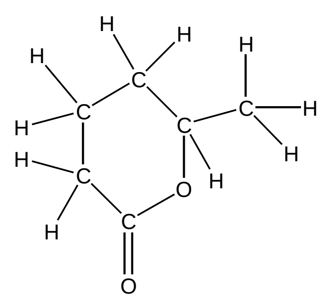
F =



G =



H =



Total 8

8. This is a question about rates of chemical reactions

(a) $BrO_3^- + 5Br^- + 6H^+ = 3Br_2 + 3H_2O$ (1)

(b) (i) 1
(ii) 1 (mark scheme 2marks for 3 correct, 1 mark for 2 correct, 0 marks for 1or1) (2)
(iii) 2

(c) $1.48 \times 10^{-2} – 1.50 \times 10^{-2}$ $mol^{-3}\ dm^{9}\ s^{-1}$ (1 mark correct value, 1 mark for units) (2)

(d) [ethanoic acid] = 0.0300 ($mol\ dm^{-3}$) (1)
$[H^+] = 7.22 \times 10^{-4}$ ($mol\ dm^{-3}$) (1)
9.91×10^{-11} ($mol\ dm^{-3}\ s^{-1}$) (1)

Total 8

9. This question is about the acid-base properties of glycine

a) A = $^{+}NH_3 . CH_2\ COOH$

B = $^{+}NH_3 . CH_2\ COO^-$ (2)

C = $NH_2 . CH_2\ COO^-$

(*mark scheme 2marks for 3 correct, 1 mark for 2 correct, 0 marks for 1or1)*

b) $^{+}NH_3 . CH_2\ COOH$

9.78 2.35

(1 mark for both parts correct)

c) At X : pH = 2.35

Y : pH = 9.78

[acid] = [salt] (1)
pH = pKa

d)(i) $H_3N^+ . CH_2\ COOH \rightleftharpoons H_3N^+ . CH_2 . COO^- + H^+$ Ka_1

$H_3N^+ . CH_2\ COO^- \rightleftharpoons H_2N . CH_2\ COO^- + H^+$ Ka_2
(1 mark for both parts correct)

(ii) $$Ka_1 = \frac{[H^+]\ [H_3N^+ . CH_2\ COO^-]}{[H_3N^+ . CH_2\ COOH]}$$

$$Ka_2 = \frac{[H^+]\ [H_2N . CH_2\ COO^-]}{[H_3N^+ . CH_2\ COO^-]}$$

(1 mark for both parts correct)

e) $$Ka_1 = \frac{[H^+]\ [^{+}NH_3 . CH_2 . COO^-]}{[^{+}NH_3 . CH_2\ COOH]}$$

$$10^{-2.35} = \frac{10^{-4}\ [^{+}NH_3\ \ CH_2\ \ COO^-]}{[^{+}NH_3\ \ CH_2\ COOH]}$$

$$\frac{[^{+}NH_3\ \ CH_2\ \ COO^-]}{[^{+}NH_3\ \ CH_2\ COOH]} = 44.6$$

(2)
Total 8