ANSWERS ROUND 1

1. This is a question about trends in chemistry

a. Na, S_8, Al, Si

b. H_2, CH_4, NH_3, LiH

c. Mg, Na, Ca, K

d. Mg^{2+}, Na^+, F^-, Cl^-

e. K, Na, Cl, F

f. Si, S, P, Cl

g. Br_2, Cl_2, O_2, N_2

h. XeF_4, OF_2, SiF_4, BF_3

i. $CH_3F, CH_3Cl, CH_3Br, CH_3I$

j. $SO_3, SO_2, NaCl, Na_2O$ *(1 mark each)*

Total **10**

2. This question is about enthalpy changes in solution

a) -525 kJ mol^{-1} per mole of Mg   *(2 marks)*
(-1 for incorrect sign or unit)

-136 kJ mol^{-1} per mole of Cu   *(2 marks)*
(-1 for incorrect sign or unit - also give marks if they give an answer applicable to their equation)
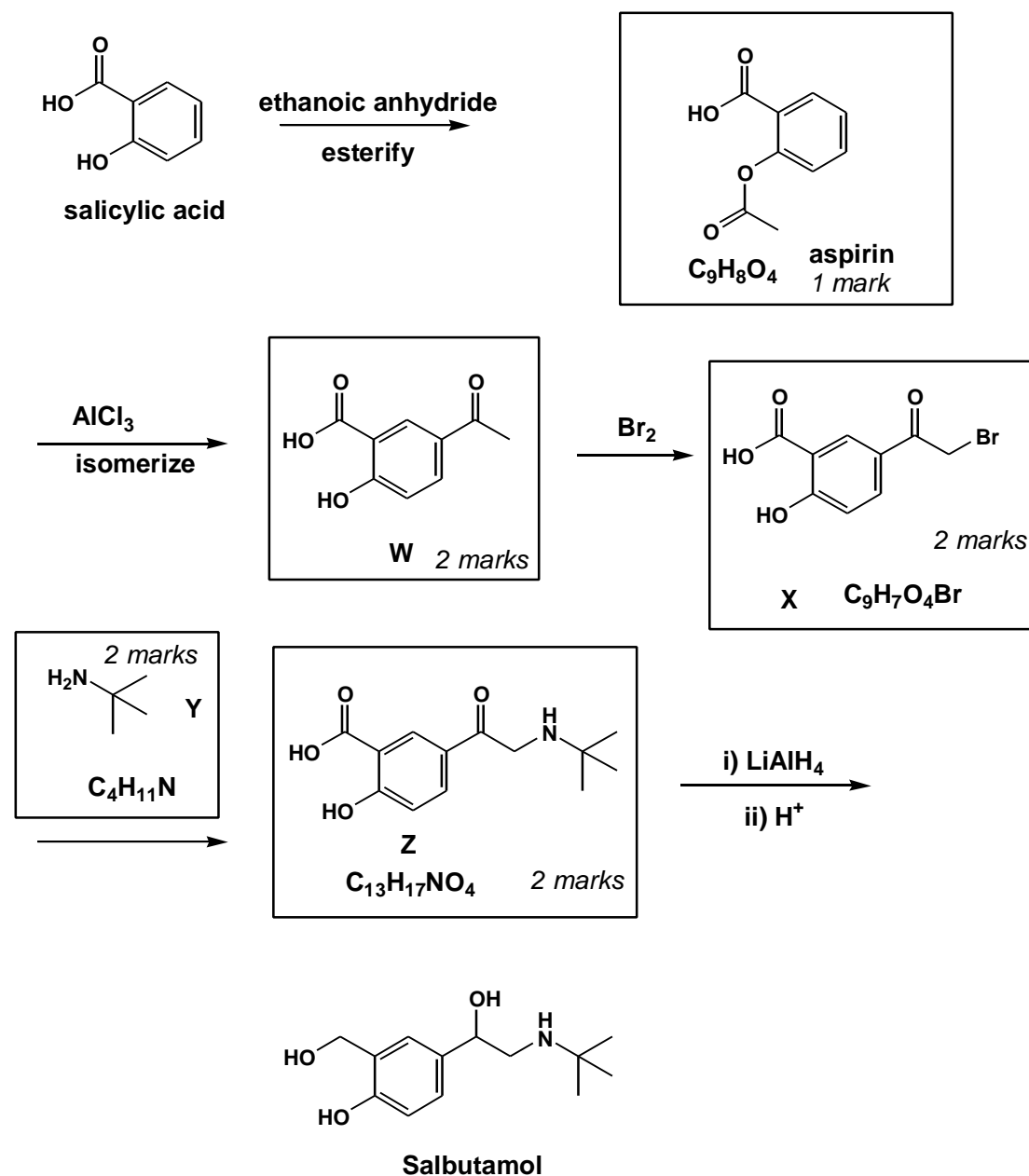
b) $\Delta H = -661$ kJ mol^{-1} of Magnesium   *(1 mark)*
(- also give mark for ecf eg added together 2 answers to part a) correctly.)

Total **5**

3. This question is about the synthesis of Salbutamol

salicylic acid → ethanoic anhydride / esterify → **aspirin** $C_9H_8O_4$ *1 mark*

AlCl$_3$ / isomerize → **W** *2 marks*

Br$_2$ → **X** $C_9H_7O_4Br$ *2 marks*

Y $C_4H_{11}N$ *2 marks* → **Z** $C_{13}H_{17}NO_4$ *2 marks*

i) LiAlH$_4$
ii) H$^+$

→ **Salbutamol**

Note – if students have drawn any of the structures slightly incorrectly then no marks should be given – ie **no part or half marks** allowed.

b) Alternative reagent = ethanoyl chloride (do not accept ethanoic acid)   (*1 mark*)

Total **10**

4. This question is about intermetallic compounds

a) IR absorption at 3400 cm^{-1} is characteristic of OH. On reduction in hydrogen, A produces 0.162 g of water which is **9 mmol = 9×10^{-3} mol**. *(1 mark)*

b) This implies that A contains 9 moles of O probably as OH. From the reaction stoichiometry, 3 moles of Cu and 1 mole of Au are probably in the product. Since 1 mmol of A weighs 0.541 g, the RMM of A should be **541**.   *(1 mark)*

3 x RMM(Cu) + 1 x RMM(Au) + 9 x RMM(OH) = RMM of A
therefore, RMM of A – (3 x 63.43) + 196.97 + (9 x 17) = 540.6
thus **A = $AuCu_3(OH)_9$**   *(1 mark)*

c) B is intermetallic which implies loss of OH to give water with the formation of $AuCu_3$. If B is 50.8% Au then it must be 49.2% Cu. Therefore Au (50.8/196.97 = **0.257**) and Cu (49/2/63.54 = **0.774**);   *(1 mark for ratios)*

0.257:0.774 = **1:3, ie $AuCu_3$**   (*1 mark for final formula*)
– (must show working to get full marks for this section)

Total **5**

5. This question is about chiral molecules

a) A B D F H   (*3 marks* – 3 marks for all 5 correct, 2 marks for 4 correct, 1 mark for 3 correct)

b) D G   *(2 marks – 1 mark each)*

c) C E   *(2 marks - 1 mark each)*

Throughout question –1 mark for every 'extra' incorrect answers given, down to zero.

Total **7**

6. This question is about inorganic analysis

Mass of barium sulphate = 3.927g

No of moles of $BaSO_4 = \dfrac{3.927}{233.37}$ *(1 mark)*

$= 0.01683$ *(1 mark)*

$= $ no of moles of $BaCl_2 + Ba(NO_3)_2$

No of moles of $Ag^+ = 21.24 \times 10^{-3} \times 0.2312 = 4.911 \times 10^{-3}$ *(1 mark)*

No of moles of Cl^- in $25cm^3 = 0.004911$

No of moles of Cl^- in $250cm^3 = 0.04911$ *(1 mark)*

No of moles of $BaCl_2 + MgCl_2 = 0.02456$

Let no of moles of $BaCl_2$ = x

∴ no of moles of $Ba(NO_3)_2 = 0.01683 - x$ *(1 mark)*
(– for trying to get barium nitrate moles)

∴ no of moles of $MgCl_2 = 0.02456 - x$

∴ Mass of $BaCl_2 = 208.26x$ g

∴ Mass of $Ba(NO_3)_2 = 261.38(0.01683 - x)$
$= 4.399 - 261.38x$ g

∴ Mass of $MgCl_2 = 95.22(0.02456 - x)$
$= 2.339 - 95.22x$ g

But total mass of sample = 5.000g

∴ 5.000 $= 208.26x + 4.399 - 261.38x + 2.339 - 95.22x$
$= -148.34x + 6.738$

148.34x $= 1.738$

x $= 0.01172$ *(3 marks)*

∴ Mass of $BaCl_2$ = 2.441g

∴ Mass of $Ba(NO_3)_2$ = 1.336g

∴ Mass of $MgCl_2$ = 1.223g *(1 mark)*

∴ % of $BaCl_2$ = 48.82

∴ % of $Ba(NO_3)_2$ = 26.72

∴ % of $MgCl_2$ = 24.46 *(1 mark)*
(must have all 3 %s)

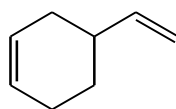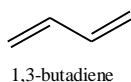Total **10**

7. This question is about the dimerization of 1,3-butadiene

a) (accept skeletal forms also)

or
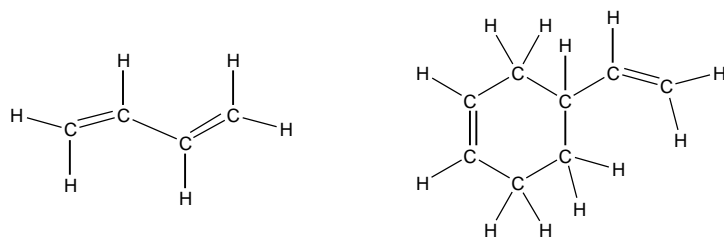
1,3-butadiene

4-ethenyl-cyclohexene   *(2 marks, 1 mark each)*

b) $(2 \times -2540) - (-4930) = -150 \text{ kJ mol}^{-1}$ *(2 marks)*

Note: must have units – 1 mark is deducted for any error eg sign, units, not x by 2

c) rate $= k\,[\text{1,3-butadiene}]^2$ *(1 mark)*

d) $A, = 4.4 \times 10^7 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$; $Ea = +108 \text{ kJ mol}^{-1}$ ($\ln A = 17.6$)   *(4 marks)*
        (2 marks for A with units, 2 marks for Ea with units. Allow 1 mark if ln A is written)

e) reverse reaction activation energy $= 108 + 150 = 258 \text{ kJ mol}^{-1}$ *(1 mark)*

Total **10**

8. This question is about structure determination using spectroscopy

Compound **A** is a liquid that boils at the same temperature as water. It gives the following combustion analysis data:

C: 64.8%; H: 13.6%; O: 21.6%.

a) Calculate the empirical formula of compound **A**.

64.8/12.00 = 5.4   13.6/1.00 = 13.6   21.6/16.00 = 1.35

Molar ratio: $C_{5.4}H_{13.6}O_{1.35}$

Divide by smallest: **$C_4H_{10}O$ = Empirical Formula**   *(1 mark)*

b) Suggest the molecular formula of compound **A**.

$C_4H_{10}O$ *(1 mark)*

c) This formula can contain one of two functional groups. Identify both of them.

Hydroxyl group –OH Ether C-O-C   *(1 mark for both)*

The infrared spectrum of compound **A** is as shown (attached):

d) What functional group can be identified in this spectrum?

Hydroxyl group – broad absorption ~3300 cm^{-1} *(NO Marks)*


e) Draw the structural formulae and give the name of each possible structure of compound **A**.

Butan-1-ol

2-Methylpropan-1-ol

Butan-2-ol

2-Methylpropan-2-ol
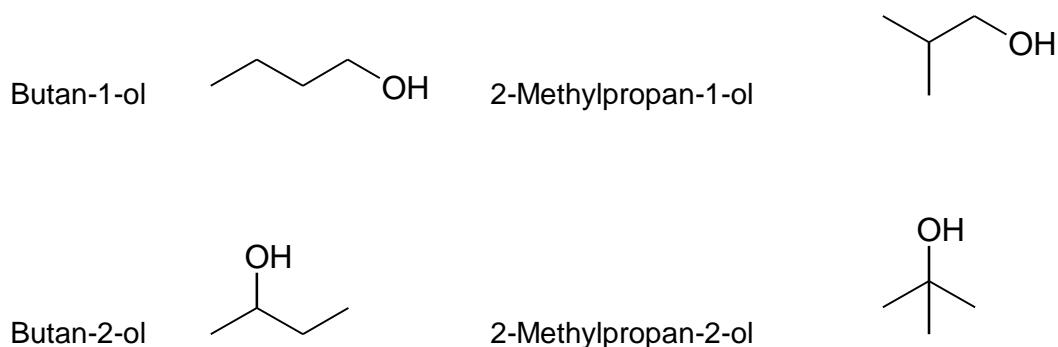
(4 marks, I for each name and structure   –1 mark for ethers etc)

Compound **A** reacts with acidified potassium manganate(VII) to give compound **B**. This new compound boils at a lower temperature than compound **A** and has the ^{1}H NMR spectrum as shown (attached):

f) Give the structural formula of compound **B** and indicate on the structure how this is consistent with the NMR spectrum.
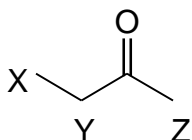
Chemical Shift ppm	Multiplicity	Integration	Assignment
0.94	triplet	(1) 3	-CH$_3$ (X)
2.04	singlet	(1) 3	-CH$_2$- (Y)
2.36	quartet	(0.66) 2	CH$_3$CO- (Z)

(2 marks - Need to include the relationship between structure and splitting)

g) How would you expect the infrared spectrum of **B** to differ from **A**?

No absorption at ~3300 cm^{-1} because there is no –OH group in compound B.

An absorption at ~1750 cm^{-1} due to the C=O group in compound B.
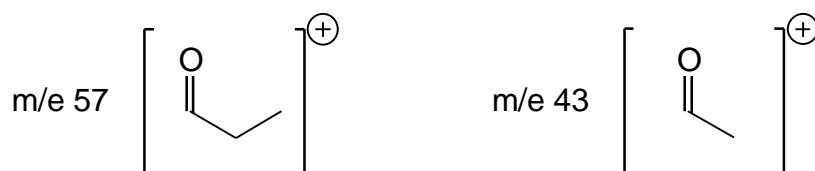
(1 mark for both parts correct)

h) Give the name of compound **B**.

Butan-2-one   (*NO marks)*

The mass spectrum of compound **B** (attached) contains fragment ions at m/e 57 and m/e 43.

i) Give the formulae of the fragment ions observed.

m/e 57   m/e 43

(1 mark for both correct - charge must be included)

Total **11**