

**2014 Preliminary Examination  
H1 Chemistry  
Paper 1 Suggested Solutions**

- 1** There are  $6.02 \times 10^{23}$  particles in 1 mol of that particle. **A**

No. of moles of electrons in 2 g of helium gas =  $2/4 \times 2 = 1$  mol

No. of moles of chlorine molecules in 35.5 g of chlorine gas =  $35.5/71 = 0.5$  mol

No. of moles hydrogen ions in 1 dm<sup>3</sup> of 1 mol dm<sup>-3</sup> sulfuric acid (H<sub>2</sub>SO<sub>4</sub>)  
=  $2 \times 1 \times 1 = 2$  mol

No. of moles of oxygen atoms in 24.0 dm<sup>3</sup> of carbon dioxide CO<sub>2</sub> at r.t.p.  
=  $2 \times 24.0/24.0 = 2$  mol

- 2** 
$$\text{C}_x\text{H}_y(\text{g}) + (x + y/4)\text{O}_2(\text{g}) \rightarrow x\text{CO}_2(\text{g}) + y/2\text{H}_2\text{O}(\text{g})$$
  

$$20\text{cm}^3 \qquad \qquad \qquad 60\text{cm}^3 \qquad \qquad \qquad 80\text{cm}^3$$
 **C**

$$\frac{x}{1} = \frac{60}{20} \Rightarrow x = 3 \qquad \frac{y}{2} = \frac{80}{20} \Rightarrow y = 8$$

Hence, formula of hydrocarbon is C<sub>3</sub>H<sub>8</sub>.

- 3** Valence electronic configuration (ground state) **A**

<sup>34</sup>Se    4s<sup>2</sup> 4p<sup>4</sup>    (2 unpaired electrons)

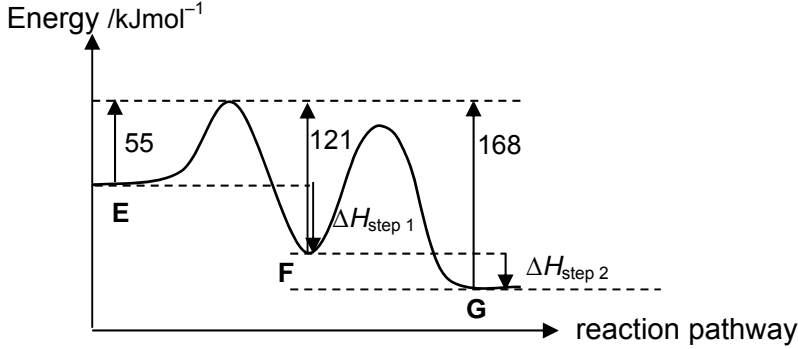
<sup>38</sup>Sr    5s<sup>2</sup>    (0 unpaired electron)

<sup>51</sup>Sb    5s<sup>2</sup> 5p<sup>3</sup>    (3 unpaired electrons)

<sup>85</sup>At    6s<sup>2</sup> 6p<sup>5</sup>    (1 unpaired electron)

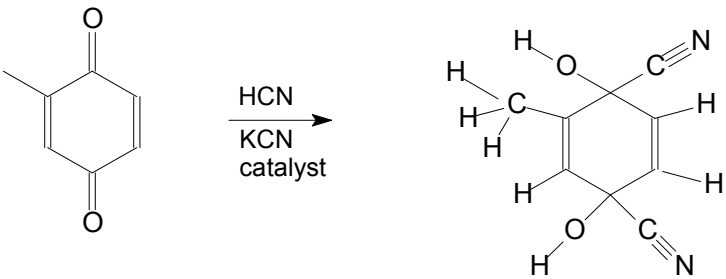
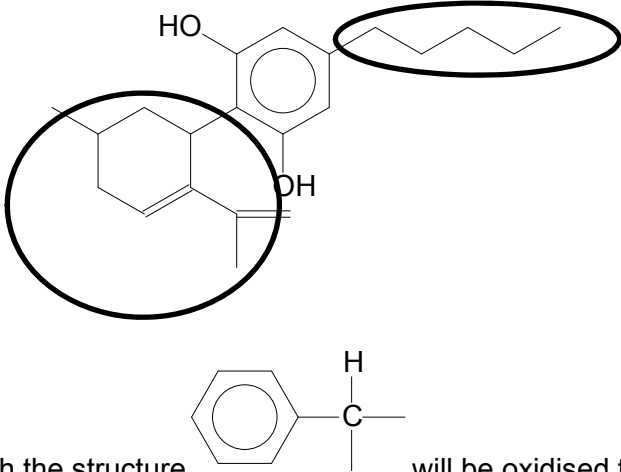
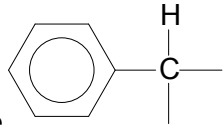
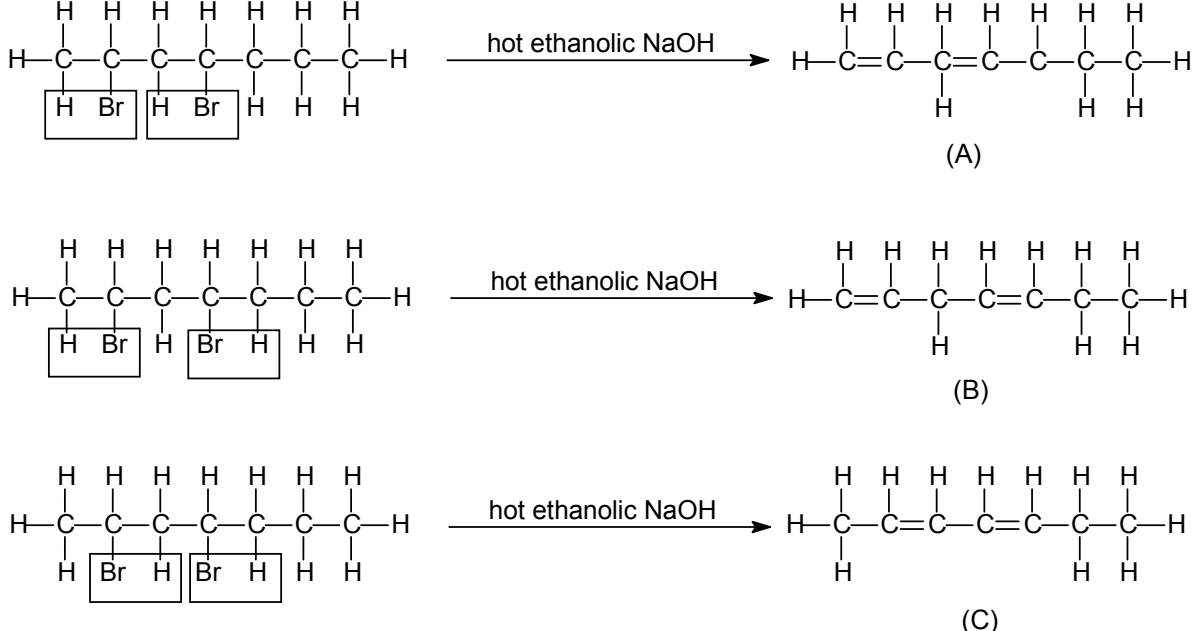
- 4** There is a big increase from the 6<sup>th</sup> IE (7000 kJ mol<sup>-1</sup>) to 7<sup>th</sup> IE (13200 kJ mol<sup>-1</sup>).  
Hence **X** should be a group VI element, <sup>52</sup>Te. **C**

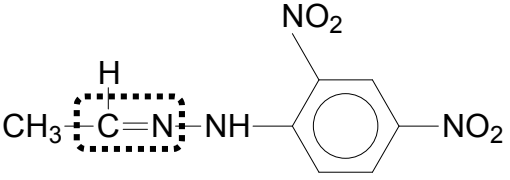
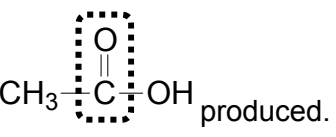
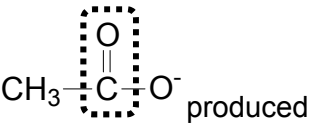
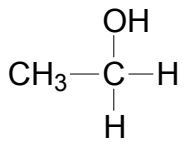
5	<div data-bbox="624 197 986 566" data-label="Chemical-Block"> </div> <p>An O atom has 6 valence electrons. Since 2 electrons are used in the formation of 2 covalent bonds in <b>a</b>, there are <b>2</b> lone pairs of electrons.</p> <p>A N atom has 5 valence electrons. Since 3 electrons are used in the formation of 3 covalent bonds in <b>b</b>, there is <b>1</b> lone pair of electrons.</p>	C
6	<p>All have simple molecular structures with weak intermolecular forces (IMF). D has the strongest IMF (hydrogen bonding) amongst them. Hence, D has the highest boiling point.</p> <p>(A and B are non-polar molecules with intermolecular van der Waals' forces of attraction. C is a polar molecule with intermolecular permanent dipole – permanent dipole attraction.)</p>	D
7	<div data-bbox="437 1016 1114 1451" data-label="Chemical-Block"> <p style="text-align: center;">yanucamide B</p> </div> <p>Carbon atom with angle <b>X</b> has 4 bond pairs arranged in a tetrahedral shape, to minimise bond pair–bond–pair repulsion. Bond angle <math>\approx 109^\circ</math></p> <p>Oxygen atom with angle <b>Y</b> has 2 bond pairs and 2 lone pairs.</p> <p>Since lone pair – lone pair repulsion &gt; lone pair – bond pair repulsion &gt; bond pair – bond pair repulsion, shape w.r.t. O atom is bent, i.e. <math>105^\circ</math>.</p>	B

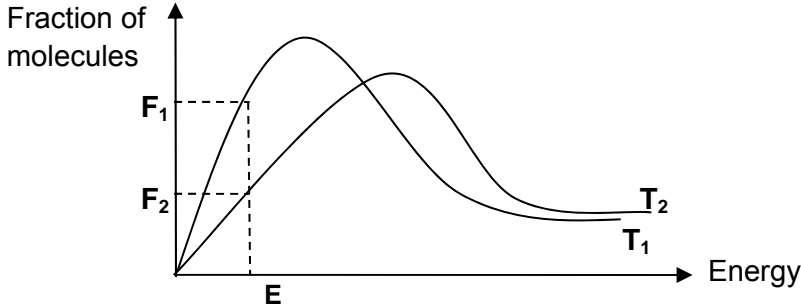
8	 <p>From the diagram, both step 1 and 2 are exothermic reactions.</p> <p>Enthalpy change of reaction for the step 1 (<math>\Delta H_{\text{step 1}}</math>) = <math>-(121 - 55) = -66 \text{ kJ mol}^{-1}</math></p> <p>Enthalpy change of reaction for the step 2 (<math>\Delta H_{\text{step 2}}</math>) = <math>-(168 - 121) = -47 \text{ kJ mol}^{-1}</math> (less exothermic than step 1)</p> <p>As step 1 is a reversible reaction, the forward and backward reaction has the same numerical value for enthalpy change but their signs are different!</p> <p>The activation energy for the backward reaction in step 1 is <math>121 \text{ kJ mol}^{-1}</math> whereas the forward reaction has activation energy of <math>55 \text{ kJ mol}^{-1}</math>.</p> <p>Enthalpy change of reaction for conversion of <b>E</b> to <b>G</b>        = Sum of enthalpy change of reaction for first step and second step        = <math>-66 - 47 = -113 \text{ kJ mol}^{-1}</math></p>	D
9	<p>From the table, it can be deduced that hydrobromic acid is a strong acid since the enthalpy change of neutralisation is <math>-57 \text{ kJ mol}^{-1}</math>. Hydrofluoric acid is a weak acid since the enthalpy change of neutralisation is less exothermic than <math>-57 \text{ kJ mol}^{-1}</math>.</p> <p>Hence, <b>P</b> and <b>Q</b> must be weak and strong acid respectively.</p>	D
10	<p>Lattice energy <math>\propto \frac{q_+ q_-}{r_+ + r_-}</math></p> <p>All cations and anions are singly charged, hence only the ionic radius needs to be considered.</p> <p><math>\text{Cs}^+</math> and <math>\text{I}^-</math> ions are the largest cation and anion respectively. Hence, lattice energy of <math>\text{CsI}</math> has the smallest numerical value.</p>	B
11	<p>Heat evolved during neutralisation        = <math>(20+20)(4.2)(15)</math></p> <p><i>Note: temperature change in Kelvin = temperature change in <math>^{\circ}\text{C}</math></i></p> <p>Moles of water formed = <math>0.04 \text{ mol}</math></p> <p><math>\therefore \Delta H = - \frac{40 \times 4.2 \times 15}{0.04}</math></p> <p><i>Note: <math>\Delta H_{\text{neutralisation}}</math> is calculated based on the number of moles of water formed.</i></p>	C

12	<p> <math>\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g}) \quad \Delta H = +53 \text{ kJ mol}^{-1}</math>            There is no change in the number of gas particles, hence the position of equilibrium (POE) is not affected by pressure change.         </p> <p> <math>4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g}); \quad \Delta H = -950 \text{ kJ mol}^{-1}</math>  <math>\text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}); \quad \Delta H = -92 \text{ kJ mol}^{-1}</math>            For options <b>B</b> and <b>C</b>, when the temperature increases, the backward endothermic reaction is favoured. POE will shift left to absorb the excess heat. As a result, the proportion of products decreases.         </p> <p> <math>\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}); \quad \Delta H = +57 \text{ kJ mol}^{-1}</math>            When the pressure is reduced, the POE will shift right to increase the pressure by increasing the number of gaseous molecules.         </p> <p>           When the temperature increases, the forward endothermic reaction is favoured. POE will shift right to absorb the excess heat. As a result, the proportion of products increases.         </p>	<b>D</b>
13	<p> <math>\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \quad \Delta H &lt; 0 \text{ (exothermic)}</math> </p> <p>By Chatelier's Principle,</p> <ul style="list-style-type: none"> <li>when <i>pressure increases</i>, the position of equilibrium (POE) shifts right to decrease pressure by producing fewer gas molecules <math>\Rightarrow</math> % <math>\text{NH}_3</math> at equilibrium increases</li> <li>when <i>temperature increases</i>, POE shifts left (as backward endothermic reaction is favoured) to reduce temperature by absorbing the extra heat <math>\Rightarrow</math> % <math>\text{NH}_3</math> at equilibrium decreases</li> </ul> <p>From the graph, since % <math>\text{NH}_3</math> at equilibrium decreases when <b>H</b> increases, <b>H</b> must be temperature.</p> <p>Therefore, <b>J</b> and <b>K</b> must be pressure.</p> <p>From the graph, since % <math>\text{NH}_3</math> at equilibrium at pressure <b>J</b> is greater than that at pressure <b>K</b> for the same temperature condition, pressure <b>J</b> must be greater than pressure <b>K</b>.</p> <p>Only option <b>C</b> is correct.</p>	<b>C</b>
14	<p>In option <b>B</b>, <math>\text{H}_2\text{SO}_4</math> is acting as an acid and <math>\text{HNO}_3</math> the base.</p> <p>Options <b>A</b>, <b>C</b> and <b>D</b> are redox reactions.</p>	<b>B</b>

15	<p>From experiment 2 and 3, when [B] is doubled, rate increases by 4 times, so order of reaction w.r.t. [B] is 2.</p> <p>From experiment 1 and 2, when [A] and [B] is doubled, rate increases by 4 times so order of reaction w.r.t. [A] is 0 since we already deduced order w.r.t. [B] to be 2.</p> <p>Hence it can be deduced that the rate equation is <b>rate = <math>k[B]^2</math></b></p> <p>By unit analysis, the units of k is <math>\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}</math></p>	A
16	<p>Option <b>B</b> is incorrect.</p> <p>Shielding effect remains <u>relatively constant</u> across the period as the additional electron is added to the same quantum shell.</p> <p>Sodium has the lowest first ionisation energy due to its <u>lowest nuclear charge</u> as it has the lowest number of proton in Period 3. Therefore, the valence electron in sodium is the least strongly attracted to the nucleus resulting in the lowest first ionisation energy.</p>	B
17	<p>The electrical conductivity of metals is due to the presence of mobile charge carriers i.e. delocalised electrons. In solid state, the metal cations are arranged in a regular lattice structure and are immobile.</p>	B
18	<p> <math display="block">\begin{array}{ccccccc} &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} \\ &amp;   &amp;   &amp;   &amp;   &amp;   &amp;   \\ \text{H} &amp; - \text{C} &amp; - \text{C} &amp; - \text{C} &amp; = \text{C} &amp; - \text{C} &amp; - \text{C} - \text{H} \\ &amp;   &amp;   &amp; &amp; &amp;   &amp;   \\ &amp; \text{H} &amp; \text{H} &amp; &amp; &amp; \text{H} &amp; \text{H} \end{array}</math>           Hex-3-ene, has two different groups attached to double-bonded carbons. Thus, it can exhibit <i>cis-trans</i> isomerism.         </p> <p> <math display="block">\begin{array}{ccccccc} &amp; &amp; &amp; \text{CH}_3 &amp; &amp; &amp; \\ &amp; &amp; &amp;   &amp; &amp; &amp; \\ &amp; \text{H} &amp; \text{H} &amp; &amp; \text{H} &amp; \text{H} &amp; \text{H} \\ &amp;   &amp;   &amp; &amp;   &amp;   &amp;   \\ \text{H} &amp; - \text{C} &amp; - \text{C} &amp; - \text{C} &amp; = \text{C} &amp; - \text{C} &amp; - \text{C} - \text{H} \\ &amp;   &amp;   &amp;   &amp; &amp;   &amp;   \\ &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; &amp; \text{H} &amp; \text{H} \end{array}</math>           3,4-dimethylhex-3-ene, has two different groups attached to double-bonded carbons. Thus, it can exhibit <i>cis-trans</i> isomerism.         </p> <p> <math display="block">\begin{array}{ccccccc} &amp; &amp; \text{CH}_3 &amp; &amp; \text{H} &amp; \text{H} &amp; \\ &amp; &amp;   &amp; &amp;   &amp;   &amp; \\ \text{H}_3\text{C} &amp; - \text{C} &amp; = \text{C} &amp; - \text{C} &amp; - \text{C} &amp; - \text{H} \\ &amp; &amp; &amp;   &amp;   &amp;   \\ &amp; &amp; &amp; \text{H} &amp; \text{H} &amp; \text{H} \end{array}</math>           Only 2-methylpent-2-ene, has two identical (<math>-\text{CH}_3</math>) groups attached to double-bonded carbons. Thus, it <b>cannot</b> exhibit <i>cis-trans</i> isomerism.         </p> <p> <math display="block">\begin{array}{ccccccc} &amp; \text{H} &amp; &amp; &amp; \text{H} &amp; \text{H} &amp; \\ &amp;   &amp; &amp; &amp;   &amp;   &amp; \\ \text{H} &amp; - \text{C} &amp; - \text{C} &amp; = \text{C} &amp; - \text{C} &amp; - \text{C} - \text{H} \\ &amp;   &amp;   &amp;   &amp;   &amp;   \\ &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} \end{array}</math>           Pent-2-ene, has two different groups attached to double-bonded carbons. Thus, it can exhibit <i>cis-trans</i> isomerism.         </p>	C

19	 <p>Note: A triple bond is made up of one <math>\sigma</math> bond and 2 <math>\pi</math> bonds</p>	D
20	Using Markovnikov's rule, D is the major product of the addition reaction.	D
21	<p>The hot concentrated potassium manganate(VII) in the presence of sulfuric acid will result in oxidation of the two alkyl side chains shown below to carboxylic acids.</p>  <p>Note: Side-chains with the structure  will be oxidised to carboxylic acid.</p>	B
22	 <p>Only the compound in option D is not formed</p>	D

23	<p>Both <b>M</b> and <b>N</b> has alkene groups which undergo addition reaction with <math>\text{Br}_2(\text{aq})</math> at room temperature and decolourise <math>\text{Br}_2(\text{aq})</math>.</p> <p>The carboxylic acid group in <b>M</b> and the alcohol group in <b>N</b> will react with sodium metal and liberate hydrogen gas.</p> <p>Both <b>M</b> and <b>N</b> will not react with Tollens' reagent as no aldehyde group is present.</p> <p><b>M</b> has a <math>\text{CH}_3\text{CO}-</math> group in its structure which will form yellow ppt of <math>\text{CHI}_3</math> with alkaline aqueous iodine. <b>N</b> does not give a <math>\text{CHI}_3</math> ppt.</p>	<b>D</b>
24	<p>The question requires recall of reagents of organic chemical reactions to produce halogen derivatives. The deuterium isotope is merely a distractor and should be treated as a hydrogen atom for analysis. As such, it should be deduced that option A is addition of alkene and B and C are substitution reactions of alcohols that will give the required organic product.</p>	<b>D</b>
25	<p>All except option D will give an organic molecule in which the reactive C atom remains trigonal planar.</p> <div style="text-align: center;">  <p>With 2,4-DNPH, produced.</p> </div> <div style="text-align: center;">  <p>With <math>\text{K}_2\text{Cr}_2\text{O}_7</math>, produced.</p> </div> <div style="text-align: center;">  <p>With Fehling's solution, produced</p> </div> <div style="text-align: center;">  <p>With sodium borohydride, produced.</p> </div>	<b>D</b>

26	 <p>The total number of molecules does not change even when temperature changes.</p> <p>When temperature decreases (<math>T_2 &gt; T_1</math>), the curve is displaced to the left and the fraction of molecules at energy <math>E</math> increases (<math>F_2 &lt; F_1</math>). Therefore, statement 3 is incorrect.</p> <p>Only statements 1 and 2 are correct.</p>	B
27	<p>All 3 statements are true.</p> <p>A catalyst increases the rate of reaction by providing an alternate pathway with lower activation energy.</p> <p>If the activation energy is high, the reaction does not take place readily as there are less reacting molecules that possess energy greater than or equals to the activation energy.</p> <p>In a reversible reaction, where the forward reaction is endothermic, the activation energy for the forward reaction is larger than that for the reverse reaction.</p>	A
28	<p><math>Al_2O_3</math> is insoluble in water but reacts with acids and bases as they are amphoteric.</p> <p><math>P_4O_6</math> is an acidic oxide. It dissolves readily in water to give strongly acidic solution, <math>H_3PO_3</math>, of pH &lt;2.</p> <p><math>SiO_2</math> is an insoluble oxide and does not hydrolyse in water. However, it reacts with a base to produce silicate (IV) ion, <math>SiO_3^{2-}</math>.</p>	B
29	<p>Aldehyde functional group (<math>-CHO</math>) does not react with sodium metal or <math>PCl_5</math>.</p> <p>Each alcohol functional group (<math>-OH</math>) reacts with sodium metal to produce 0.5 mol of <math>H_2</math> gas.</p> <p>Each alcohol functional group (<math>-OH</math>) reacts with 1 mol of <math>PCl_5</math> to produce <math>HCl</math>.</p> <p>Aldehydes and alcohols do not react with aqueous bromine.</p>	B



**30** Heating under reflux with acidified potassium manganate(VII) will cleave the C=C bonds and hydrolyse the ester (since both heat and an acid is present) to produce three organic products.

**D**

Base-catalysed hydrolysis of the ester will produce sodium butanoate whereas butanoic acid is produced from acid-catalysed hydrolysis. Hence statement 3 is incorrect.

