MARK SCHEME for the October/November 2007 question paper

9701 CHEMISTRY

9701/02  Paper 2 (Theory 1), maximum raw mark 60

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1  (a)

\[
\begin{align*}
\text{spherical (1)} & \quad \text{larger spherical (1)} \\
\text{double lobes along the x-axis (1)} & \quad \text{[3]}
\end{align*}
\]

(b)  (i)  attraction between bonding electrons and nuclei (1)
attraction is electrostatic (1)

(ii)  \( H_2 \)  s-s overlap clearly shown (1)
\begin{align*}
\text{must not be normal dot/cross diagram} & \quad \text{(1)}
\end{align*}

HCl  s-p overlap clearly shown (1)
\begin{align*}
\text{overlap must involve s and p orbitals} & \quad \text{(1)}
\end{align*}  [4]

(c)  (i)  bonding electrons are unequally shared or (1)
the molecule has a dipole/\( \delta^+ \) and \( \delta^- \) ends to molecule (1)

(ii)  the H and Cl atoms have different electronegativities (1)
\begin{align*}
\text{or chlorine is more electronegative than hydrogen} & \quad \text{(1)}
\end{align*}  [2]
(d) **allow** two ‘sausages’ above and below the C-C axis **or** two p orbitals **overlapping** sideways to form one (localised) \( \pi \) bond over two carbon atoms (1) [1]

(e) \( \Delta H_f = 2(-393.7) + 2(-285.9) - (-1411) \)

\[ = + 51.8 \text{ kJ mol}^{-1} \text{(units given in qu.)} \] (3)

penalise errors: no 2 for –393.7
no 2 for –285.9
wrong sign for –(-1411) [3]

[Total: 13]

2 (a) \( P_4(s) + 10Cl_2(g) \rightarrow 4PCl_6(s) \)

**or** \( 2P(s) + 5Cl_2(g) \rightarrow 2PCl_5(s) \)

equation (1) [2]

state symbols (1)

(b) (i) giant ionic lattice (may be in diag.) (1)

strong ionic bonds (1)

(ii) simple molecular **or** discrete molecules (may be shown in a diagram) (1)

with **weak** intermolecular forces **or** **weak** van der Waals’ forces (1) [4]

(c) \( SiC_4 + 2H_2O \rightarrow SiO_2 + 4HCl \)

**or** \( SiC_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl \)

**or** \( SiC_4 + 4H_2O \rightarrow SiO_2\cdot2H_2O + 4HCl \) (1) [1]
(d) NaCl pH is 7 allow neutral (1)

PCl₅ pH is between 1 and 4
do not allow acidic (1) [2]

(e) (i) 460 K Al₂Cl₆ (1)

1150 K AlCl₃ (1)

(ii) correct dot-and-cross diagram for AlCl₃ (1)

(iii) correct displayed structure for Al₂Cl₆ (1)
two correct co-ordinate bonds (1)

[Total: 14]

3 (a) P₄ (1)

S₈ (1)

Cl₂ (1) [3]

(b) (i) highest S₈ ........ P₄ .......... Cl₂ lowest allow S ... P ... Cl or names (1)

(ii) from S₈ to P₄ to Cl₂

there are fewer electrons in each molecule (1)
hence weaker van der Waals' forces (1) [3]
(c) (i) \(S_2Cl_2 = (2 \times 32.1) + (2 \times 35.5) = 135.2\)

\[n(S_2Cl_2) = \frac{2.7}{135.2} = 0.0199 = 0.02\] (1)

\[0.02 \text{ mol } S_2Cl_2 \rightarrow \frac{0.96}{32.1} = 0.03 \text{ mol } S\] (1)

\[1.0 \text{ mol } S_2Cl_2 \rightarrow \frac{0.03 \times 1.0}{0.02} = 1.5 \text{ mol } S\] (1)

(iii) \(2S_2Cl_2 + 3H_2O \rightarrow 3S + H_2SO_3 + 4HCl\)

correct products (1) balanced equation (1) [4]

(d) oxidation product is \(H_2SO_3\) (1)

reduction product is \(S\) (1) [2]

[Total: 12]

4 (a) 

\[
\begin{align*}
\text{cis} & \quad \text{trans} \\
\text{H atoms must be shown.} & \\
\text{Structure must not contain any CH}_3\text{ groups} & (1) [1]
\end{align*}
\]

(b) 

\[
\begin{align*}
\text{cis} & \quad \text{trans} \\
\text{H}_3C & \quad \text{H}_3C \\
\text{H} & \quad \text{H} \\
\text{C=}[ & \quad \text{C=} \\
\text{H}_2C & \quad \text{H}_2C \\
\text{H}_3C & \quad \text{H}_3C \\
\text{H} & \quad \text{H}
\end{align*}
\]

(c) \(CH_3CH(OH)CH_2CH_2CH_3\) (1) \(CH_3CH_2CH(OH)CH_2CH_3\) (1) [2]
(d) correct compound
   correct mirror object/mirror image relationship in 3D (1) [2]

(e) e.g. cyclopentane structure
   allow methylcyclobutane or dimethylcyclopropane (1) [1]

(f) e.g.
   two repeat units must be shown
   relative positions of –CH₃ and –C₂H₅ may differ from those shown above (1) [1]

[Total: 9]

5 (a) (i) Cr₂O₇²⁻/H⁺ allow MnO₄⁻/H⁺ (1)
   (ii) from orange to or purple to colourless green or green/blue (1) [2]

(b) (i) to ensure complete oxidation of –CH₂OH
   or to keep reactants in the reaction flask (1)
   (ii) CH₃CHO/ethanal (1) [2]

(c) (i) CH₃I/iodomethane (1)
   (ii) nucleophilic substitution or hydrolysis (1) [2]
(d) step I

red $\text{P} + I_2$ or $\text{HI(aq)}$ or $\text{KBr/conc H}_3\text{PO}_4$ or $\text{PI}_3$ (1)

heat **but** room temperature for $\text{PI}_3$ (1)

step II

$\text{KCN}$ in aqueous ethanol (1)

in aqueous ethanol, heat under reflux (1)

allow aqueous ethanol in either place

step III

aqueous mineral acid (**not** nitric acid) (1)

or $\text{NaOH(aq)}$ then aqueous mineral acid (1)

heat (1) [6]

[Total: 12]