MAXIMUM MARK: 60
Mark scheme abbreviations
;
 separates marking points
 /
 alternative answers for the same point
 R
 reject
 A
 accept (for answers correctly cued by the question, or by extra guidance)
 AW
 alternative wording (where responses vary more than usual)
 underline
 actual word given must be used by candidate (grammatical variants excepted)
 max
 indicates the maximum number of marks that can be given
 ora
 or reverse argument
 mp
 marking point (with relevant number)
 ecf
 error carried forward
 I
 ignore
 AVP
 Alternative valid point (examples given as guidance)
1 (a) fewer electrons in Cl₂ than in Br₂ or (1)
weaker van der Waals’ forces in Cl₂ or stronger van der Waals’ forces in Br₂ (1) [2]

(b) CO has a permanent dipole or N₂ does not (1)
permanent dipole-permanent dipole interactions are stronger than those from induced dipoles (1) [2]

(c) a co-ordinate bond (1)

a covalent bond (1)

or

a lone pair (1)

or

penalise any groups of 3 or 4 electrons that are circled [3]

(d) CO and HCN both have a dipole or N₂ does not have a dipole [1]

(e) (i) 

H – C – C – O – H

H C ≡ N

C ≡ N must be shown [1]

(ii) nucleophilic addition [1]
2 (a) (i) new graph has lower maximum and maximum is to the right of previous maximum [1]

(ii) H is at $E_a$ [1]

(b) the minimum amount of energy molecules must have or energy required (1) in order for the reaction to take place (1) [2]

(c) (i) iron or iron oxide
100 to 500 atm and 400–550 °C
units necessary – allow other correct values and units [1]

(ii) C is placed to the left of H [1]

(iii) more molecules now have energy $> E_a$ [1]

(d) (i) reaction 1 has greater $E_a$ (1)
because energy is needed to break covalent bonds (1)

reaction 2 has lower $E_a$ (only valid if converse not awarded for reaction 1)
or actual reaction is $H^+ + OH^- \rightarrow H_2O$
or reaction involves ions (1)
opposite charges attract (1) [4]

(ii) alkaline aqueous iodine (1)
yellow ppt (1) [2]

[Total: 13]
3  (a) Accept only symbols.

   (i) K or K$^+$ [1]
   (ii) Na – allow K or Li [1]
   (iii) Cl or Br [1]
   (iv) Mg or Ca or Li [1]

(b) Accept only formulae.

   (i) F$_2$O [1]
   (ii) SO$_2$ and SO$_3$
        or P$_2$O$_3$/P$_4$O$_6$ and P$_2$O$_5$/P$_4$O$_{10}$
        or any two from N$_2$O$_3$, NO$_2$/N$_2$O$_4$, N$_2$O$_5$
        or any two from Cl$_2$O, ClO$_2$, ClO$_3$, Cl$_2$O$_7$ (1 + 1) [2]
   (iii) SiO$_2$ or Al$_2$O$_3$ or MgO [1]
   (iv) giant structure (1)
        strong covalent bonds (1) [2]

(c) (i) octahedral [1]

(ii) I atom is larger than Cl atom (1)

        cannot pack 7 F atoms around Cl atom
        or can pack 7 F atoms around I atom (1) [2]

[Total: 13]
4 (a) CH₃CHBrCH₂Br → \text{Br}_2  \rightarrow \text{CH}_3\text{CH}=\text{CH}_2  \rightarrow \text{CH}_3\text{CH(OH)}\text{CH}_2\text{OH}  \\
\text{CH}_3\text{CH}(\text{CN})\text{CH}_3  \rightarrow \text{KCN in aqueous ethanol}  \rightarrow \text{CH}_3\text{CHBrCH}_3  \rightarrow \text{CH}_3\text{CH(NH}_2\text{)}\text{CH}_3  \\
\text{H}_2\text{SO}_4(\text{aq}) \text{ heat under reflux}  \rightarrow \text{CH}_3\text{CH(\text{CO}_2\text{H})CH}_3  \\
\text{NaOH(}in \text{ ethanol}) \text{ heat under reflux}  \rightarrow \text{CH}_3\text{CH}=\text{CH}_2

1 \text{ for each correct structure (7 × 1)} [7]

(b) (i) CH₃CH₂CH₂Br [1]
(ii) inductive effect of alkyl groups (1) stabilises secondary carbocation cf primary (1) [2]

[Total: 10]
5 (a) (i) same molecular formula but different structural formula/structure
   
   (ii) asymmetric C atom/chiral centre present (1)
        \( \text{>C=C< bond present (1) } \) [2]

(b) (i) no because there is no chiral carbon atom present [1]

(ii)
\[
\begin{align*}
\text{HO}_2\text{CCH}_2\text{CO}_2\text{H} \\
\text{CH}_3
\end{align*}
\]

(c) \( \text{C : H : O } = \frac{35.8}{12} : \frac{4.5}{1} : \frac{59.7}{16} \) this mark is for correct use of A<sub>r</sub> values (1)

\[
\begin{align*}
\text{C : H : O } & = 2.98 : 4.5 : 3.73 \\
\text{C : H : O } & = 1 : 1.5 : 1.25 \text{ this mark is for evidence of correct calculation (1)}
\end{align*}
\]

This gives empirical formula of \( W \) is \( \text{C}_4\text{H}_6\text{O}_5 \) [2]

(d) \( n(\text{OH}^-) = 1.00 \times 29.4/1000 = 0.0294 \) (1)

\[
\begin{align*}
n(W) & = \frac{1.97}{134} = 0.0147 \text{ (1)} \\
\text{no. of } -\text{CO}_2\text{H groups present} \\
in \text{one molecule of } W & = \frac{0.0294}{0.0147} = 2 \text{ (1)} \text{ [3]}
\end{align*}
\]

[Total: 11]