calcium bromide

$\text{KHCO}_3$

potassium permanganate

iron(III) nitrate

1s$^2$ 2s$^2$ 2p$^6$
1s$^2$ 2s$^2$ 2p$^6$ 3s$^2$ 3p$^5$

<table>
<thead>
<tr>
<th>Structure</th>
<th>Tetrahedral</th>
<th>Trigonal Pyramidal</th>
<th>Octahedral</th>
<th>Octahedral</th>
<th>Tetrahedral</th>
<th>Tetrahedral</th>
<th>Linear</th>
<th>Linear</th>
<th>Trigonal Bipyramidal</th>
<th>T-shaped</th>
</tr>
</thead>
<tbody>
<tr>
<td>H−N−H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F−B−F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O=C=O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl−Cl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Dissolve the manganese chloride in water.
\[
\text{MnCl}_2(s) \rightarrow \text{Mn}^{2+}(aq) + 2\text{Cl}^-(aq)
\]
Add a solution of sodium carbonate. Manganese carbonate will precipitate.
\[
\text{Mn}^{2+}(aq) + \text{CO}_3^{2-}(aq) \rightarrow \text{MnCO}_3(s)
\]
Filter off and wash the precipitate and then dissolve it in dilute sulfuric acid.
\[
\text{MnCO}_3(s) + 2\text{H}^+(aq) \rightarrow \text{Mn}^{2+}(aq) + \text{H}_2\text{O(l)} + \text{CO}_2(g)
\]
Evaporate the solution to give manganese sulfate.
\[
\text{Mn}^{2+}(aq) + \text{SO}_4^{2-}(aq) \rightarrow \text{MnSO}_4(s)
\]

• Both are ionic compounds with strong electrostatic forces between the oppositely charged particles. The energy required to overcome these attractions is called the lattice enthalpy. When the ions dissolve in water strong bonds are formed between the ions and the polar water molecules. The energy released in this process is called the solvation enthalpy. If the solvation enthalpy exceeds the lattice enthalpy the compound will be soluble. OR

Sodium chloride is soluble because the magnitude of:
\[
\Delta H \text{ for } \text{NaCl}(s) \rightarrow \text{Na}^+(g) + \text{Cl}^-(g)
\]
is less than the magnitude of
\[
\Delta H \text{ for } \text{Na}^+(g) \xrightarrow{\text{H}_2\text{O}} \text{Na}^+(aq) + \Delta H \text{ for } \text{Cl}^-(g) \xrightarrow{\text{H}_2\text{O}} \text{Cl}^-(aq)
\]
Magnesium oxide is insoluble because the magnitude of:
\[
\Delta H \text{ for } \text{MgO}(s) \rightarrow \text{Mg}^{2+}(g) + \text{O}^{2-}(g)
\]
is greater than the magnitude of
\[
\Delta H \text{ for } \text{Mg}^{2+}(g) \xrightarrow{\text{H}_2\text{O}} \text{Mg}^{2+}(aq) + \Delta H \text{ for } \text{O}^{2-}(g) + \text{H}_2\text{O} \rightarrow 2\text{OH}^-(aq)
\]

2009-J-5
• \[
\text{Pb(NO}_3)_2(s) \rightarrow \text{Pb}^{2+}(aq) + 2\text{NO}_3^-(aq)
\]
\[
\text{Pb}^{2+}(aq) + 2\text{I}^-(aq) \rightarrow \text{PbI}_2(s) \xrightarrow{\text{H}_2\text{O}}
\]
4.61 g
0.100 M

2009-J-6
• \[
1 \times 10^{15} \text{ s}^{-1} \quad 400 \text{ kJ mol}^{-1} \quad (300 \text{ nm} \text{ is } 1 \text{ significant figure})
\]
• \[
\text{Pb}_3\text{O}_4
\]

2009-J-7
• \[
1.9 \times 10^2 \text{ L}
\]
• \[
2.7 \times 10^{-5} \text{ M}
\]

2009-J-8
• \[
4\text{CH}_2=\text{CHCN} + 2\text{H}_2\text{O} \rightarrow 2\text{NC(CH}_2)_4\text{CN} + \text{O}_2
\]
• 60.5 kg
2009-J-9

- \( \text{WO}_3(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow \text{W}(\text{s}) + 3\text{H}_2\text{O}(\text{g}) \)

\[ K_p = \frac{p^3(\text{H}_2\text{O})}{p^3(\text{H}_2)} \]

\[ K_p = K_c \]

\( p(\text{CO}) = 0.264 \text{ atm} \quad p(\text{CO}_2) = 0.714 \text{ atm} \)

2009-J-10

- \(-1007 \text{ kJ mol}^{-1}\)

Reaction is spontaneous as \( \Delta G < 0 \).

- \(78.9 \text{ kJ mol}^{-1}\) \((\Delta H = -78.9 \text{ kJ mol}^{-1})\)

2009-J-11

- 1.9 J

- H-bonding

\[
\begin{align*}
\text{H}_3\text{C} & \text{C} \quad \text{O} \quad \text{H} \\
\text{O} & \quad \text{C} \quad \text{CH}_3
\end{align*}
\]

- 0.025

2009-J-12

- Water. It has much stronger intermolecular forces (H-bonds) than acetone (dispersion and dipole-dipole forces).

- The major intermolecular forces in HCl, HBr and HI are dispersion forces. The heavier the halogen, the more electrons it has, the more polarisable its electron cloud and the stronger the dispersion forces. Therefore melting points increase HCl < HBr < HI.

F is a very small and very electronegative atom. The H–F bond is therefore highly polarised and H-bonds form. These are much stronger than dispersion forces and so HF has an anomalously high m.p. As seen by the experimental order given, this is enough to raise its m.p. above that of HBr, but not above that of HI.

- The C–H bond in CHCl₃ is quite polarised due to the electron-withdrawing effect of the Cl atoms. The polar water molecules can interact better with the polar CHCl₃ molecules than with the non-polar CCl₄ molecules so CHCl₃ is more soluble.