Most of the lighter elements (at. no. up to 20) are essential elements. They are readily available in nature, so more likely to be utilised by organisms. Similarly most of the lighter d-block elements (Sc - Zn) are essential (utilised in redox and electron transport systems in the body) whereas the heavier transition metals are generally toxic.

The second ionisation of Na will be off the scale as a core electron is ionised. (Actual value > 4500 kJ mol$^{-1}$) Mg$^+$ is isoelectronic with Na, Al$^+$ is isoelectronic with Mg, etc., so the second ionisations of the other elements follow the same trends as the first ionisations (for exactly the same reasons), but displaced one atomic number to the right and at a slightly higher energy (as $Z_{eff}$ is greater).

Ca(CH$_3$CO$_2$)$_2$(s) → Ca$^{2+}$(aq) + 2CH$_3$CO$_2$–(aq)

Water would be a gas. The other hydrides of group 16 elements increase in b.p. as the molar mass increases, due to the increase in dispersion forces. H$_2$S is a gas. H$_2$O has an anomalously high b.p. due to H-bonds. Without H-bonds it would have a b.p. below that of H$_2$S.

Henry's law states that the higher the pressure of gas above a liquid, the greater the solubility of the gas in that liquid: $c = kP$

Normal air is 21% O$_2$. Anaesthetists can ensure a patient receives enough O$_2$ during surgery by increasing the % (i.e. partial pressure) of O$_2$ in the gas the patient breathes. This is the most practical and easy approach. The alternative would be to get the patient to breathe a mixture of air at a pressure greater than 1 atm, but this would be more difficult to control and could lead to other problems (e.g. "the bends").

5.5 g

Graph B is correct.

Graphs A and C: As $K_c = 2$, the reaction does not go anywhere near to completion. Graphs A and C can therefore be rejected because at least one reagent in both these graphs has dropped to 0. Also, in Graph C, the rates of change of [Br$_2$] and [Cl$_2$] are different, at variance with the stoichiometry of the reaction.

Graph D: Cl$_2$ is the limiting reagent, so the maximum [BrCl] that can form is twice the initial [Cl$_2$]. Clearly more than this has formed at equilibrium.
• 12 hours
• CO$_2$(aq) and HCO$_3^-$ (aq) constitute a buffer system:

$$\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{HCO}_3^-(\text{aq}) + \text{H}^+(\text{aq})$$

Excess H$^+$ is removed by: HCO$_3^-$ (aq) + H$^+$ (aq) → CO$_2$(aq) + H$_2$O(l)

Excess OH$^-$ is removed by: CO$_2$(aq) + OH$^-$ (aq) → HCO$_3^-$ (aq)

Hyperventilation removes CO$_2$ from the blood. This shifts the above buffer equilibrium to the left (Le Chatelier's principle), [H$^+$ (aq)] decreases and the blood pH increases.

The molecules need to be orientated correctly and they need to have enough energy (above the activation energy, $E_a$) for a reaction to occur.

The relationships between the activation energy, $E_a$, the temperature, $T$, and the rate constant, $k$, are summarised by the Arrhenius equation, $k = A e^{-E_a/RT}$. This shows that the higher the activation energy, the lower the rate constant and the lower the reaction rate.

• The auto-ionisation of water is an endothermic reaction

$$2\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq}) \quad \Delta H > 0.$$ 

Increasing the temperature will push this reaction to the right, so the [H$_3$O$^+$ (aq)] will increase and the pH will therefore decrease.

Pure water is neutral as [H$_3$O$^+$ (aq)] = [OH$^-$ (aq)]

• $sp^2$ bent
• $sp^2$ trigonal planar
• $sp^3$ trigonal pyramidal

N#1 is basic. The "lone pair" on N#2 is part of the aromatic system. The lone pair on N#1 is not, so is available to accept a proton.

Polaramine has a basic aromatic N and an aliphatic N separated by 5 bonds, as does histamine. It is therefore likely that it will compete with histamine for the binding sites of certain enzymes in the body and thus block the effects of histamine.

It rotates plane polarised light in a clockwise direction.

• SOCl$_2$

NaN(CH$_3$)$_2$ or HN(CH$_3$)$_2$ followed by OH$^-$

excess CH$_3$OH / H$^+$ catalyst / heat
2009-J-10

- $\beta$
  reducing

\[ \text{anomeric carbon} \]

\[
\begin{array}{c}
\text{CHO} \\
\text{H} - \text{OH} \\
\text{H} - \text{OH} \\
\text{H} - \text{OH} \\
\text{CH}_2\text{OH}
\end{array}
\]

nucleoside

nucleotide

ribose—phosphate
When HX adds across the double bond of an unsymmetrical alkene, the H goes to the carbon that already has the greater number of H's attached. This occurs because the relative stabilities of the intermediate carbocations that can form in this reaction have the following order: tertiary > secondary > primary > CH$_3^+$.

* e.g.

The tertiary carbocation produced in the top reaction is more stable than the primary carbocation produced in the bottom reaction, so the major pathway is the top reaction.
2009-J-12

- Yes. It has a number of charged groups that will be solvated by water molecules due to ion-dipole interactions.

2009-J-13

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