FUNDAMENTALS OF CHEMISTRY 1B (CHEM1002)

November 2000 - Part A

Q1. Al_2O_3

potassium dichromate

$Ca(CH_3CO_2)_2$

hexaaquairon(III) ion

$Na_2[Pb(OH)_4]$

sodium dicyanoargentate

$[Cu(NH_3)_4]SO_4$

ammonia

$Fe_3(PO_4)_2$

ammonium sulfate

Q2. (a) (i) potassium (K)

(ii) cobalt (Co)

(b) Paramagnetism is common in d-block elements, but rare in s-block.
Compounds of d-block elements commonly coloured; those of s-block usually white.
Variable valence in compounds; s-block normally only have a single state.

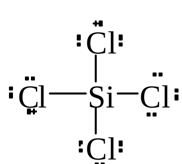
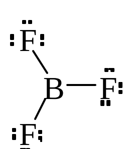
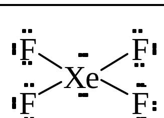
(c) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ (note that it's an ion)

(ii) $1s^2\ 2s^2\ 2p^6\ 3s^2$

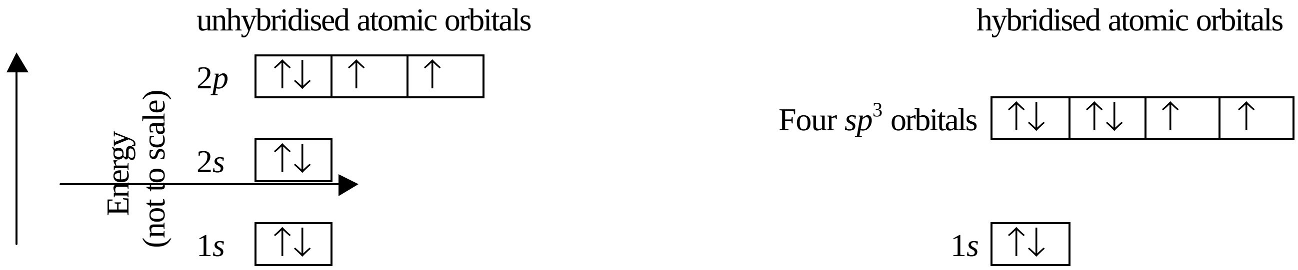
(d) $Li(g) \rightarrow Li^+(g) + e^-$ (NB must be gas phase)

Q3. Noble gas atoms (apart from He) have the structure s^2p^6 for their outer electrons. This corresponds to the outer electrons experiencing the maximum effective nuclear charge, so removal of an electron requires a lot of energy. Any electrons gained would have to occupy an orbit in a higher shell and thus suffer considerable screening by the inner electrons – ie. forming bonds by gaining electrons is also energetically unfavourable.

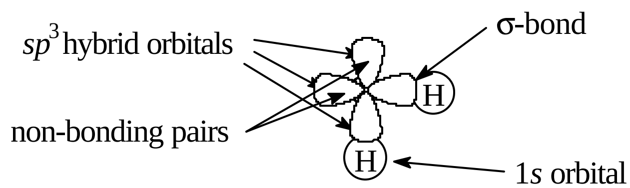
Q4.

	tetrahedral	tetrahedral
	trigonal planar	trigonal planar
	octahedral	square planar

Q5.



The 2*s*, $2p_x$, $2p_y$ and $2p_z$ orbitals of the oxygen atom undergo a mixing process called hybridisation to produce four equivalent sp^3 hybrid orbitals. Two of these orbitals already contain 2 electrons (the non-bonding pairs on the oxygen). Each of the other two sp^3 orbitals that contain 1 electron can overlap with the 1*s* orbital of a H atom to form a σ-bond.



Q6. Ammonia is a weak base, reacting with water to form hydroxide ions.

$$NH_3 + H_2O \rightleftharpoons NH_4 + OH^-$$

The initial light blue precipitate is copper(II) hydroxide.

$$Cu^{2+}(aq) + NH_3 + 2H_2O \rightarrow Cu(OH)_2(s) + 2NH_4^+(aq)$$

In excess NH_3, Cu^{2+} forms the complex ion $[Cu(NH_3)_4]^{2+}$, which is more associated than $Cu(OH)_2$. Hence the initial precipitate of $Cu(OH)_2$ dissolves.

$$Cu(OH)_2(s) + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 2OH^-(aq)$$

Q7. The atomic radius of atoms higher in a group is smaller than for atoms lower down. The outer electrons of the higher atoms are less screened by the inner electrons and experience a stronger attraction to the nucleus, requiring more energy to remove them.

Q8. Benzene has delocalised π-electrons spread over all six carbon atoms, resulting in a smaller charge density and greater stability. Cyclohexene has a higher charge density between a pair of carbon atoms and is more susceptible to attack by electron-seeking species.

Q9. The most effective buffer at a given pH would be chosen so that the pK_a of the weak acid is close to the desired buffer pH. Also, high concentrations of both weak acid and its conjugate base should be used if large buffer capacity is required.

Q10. (a) (i) pH = 2.60

(ii) pH = 8.88

(b) $[CH_3CO_2^-]$ = 1.74 M

Q11. A weak acid typically has a pK_a between 0 and 14. The pK_b of its conjugate base would therefore be between 14 and 0; ie, it would be a weak base. A strong base has a $pK_b < 0$ and would react complete with water to give OH^- and its conjugate acid (which would have a $pK_a > 14$). Such an acid is so weak that it has no significant reaction with water at all and it is not generally called an acid.

Q12. (a) A weak acid or base in a titration ends up as its conjugate base or acid, respectively. The will therefore be behaving as a base (pH > 7) or acid (Ph < 7). Only titrations of strong acid against strong base form products that do not behave as an acid or base (ie have pH = 7).

(b) phenolphthalein

Q13. END POINT = where the indicator changes colour.

EQUIVALENCE POINT = when the moles of titrants have been match exactly.

Q14.

ammonium ion	<	hydrogen cyanide	<	carbonic acid	<	hydrogen chloride
NH_4^+	<	HCN	<	H_2CO_3	<	HCl

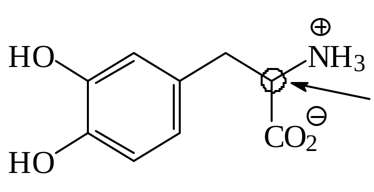
Q15. Carbonate ion is a weak base

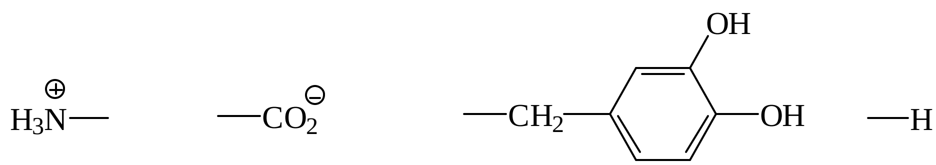
$$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$$

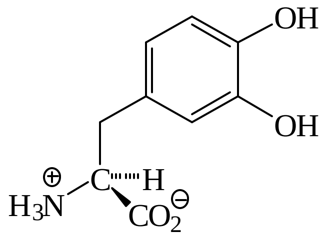
Therefore the pH > 0.

November 2000 - Part B

00-N-2



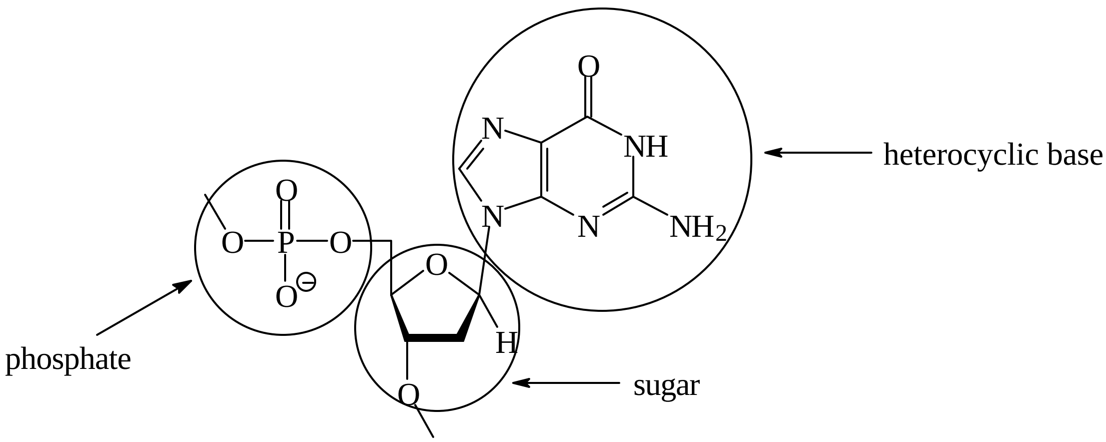




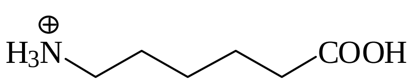
00-N-2 (cont)

DNA (deoxyribonucleic acid)

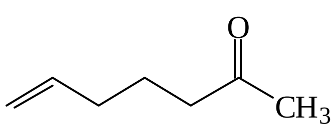
nucleotide



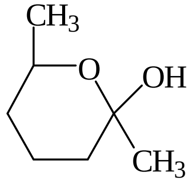
00-N-3 amide



00-N-4



hot dilute H_2SO_4



2

4

hemiacetal