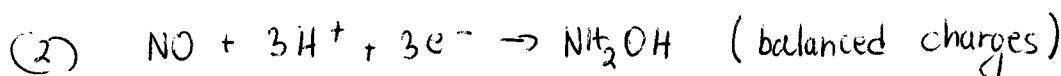
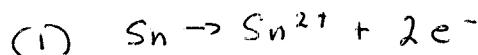
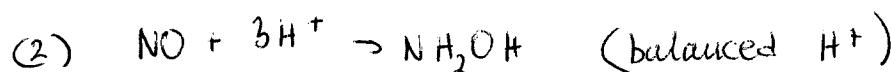
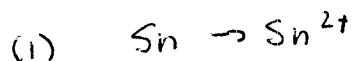
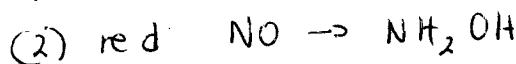
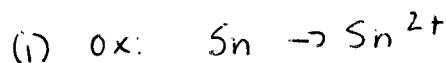
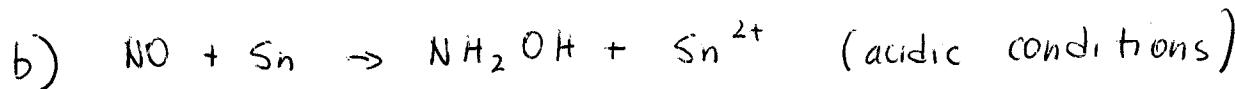
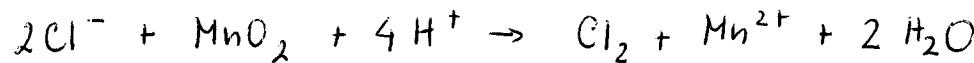
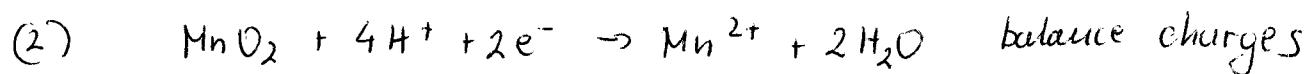
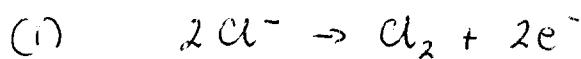
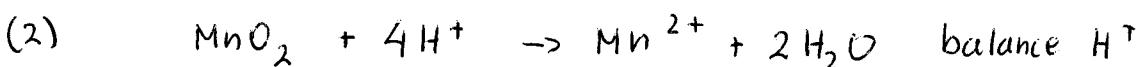
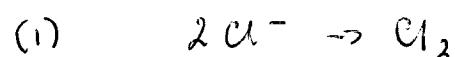
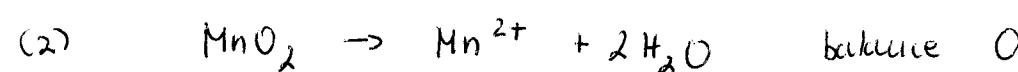
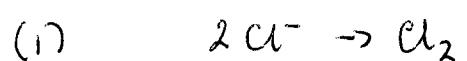
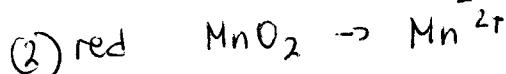
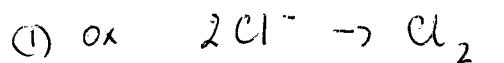
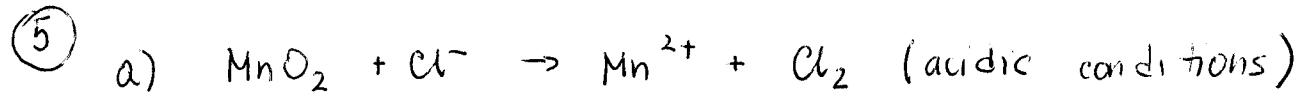
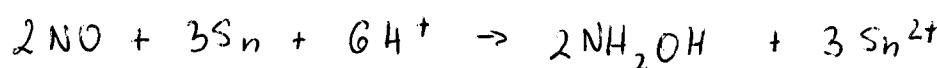
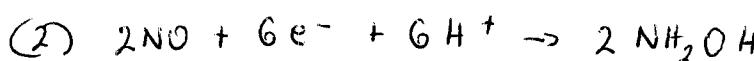
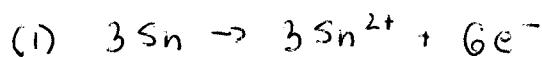


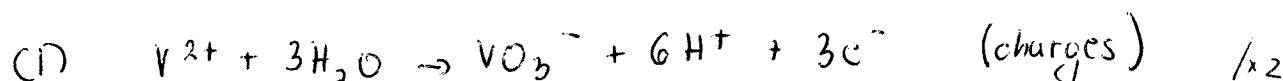
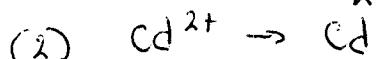
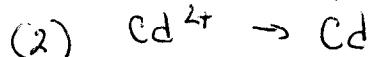
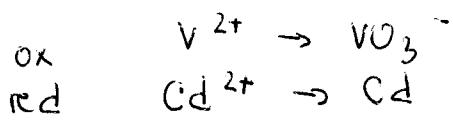
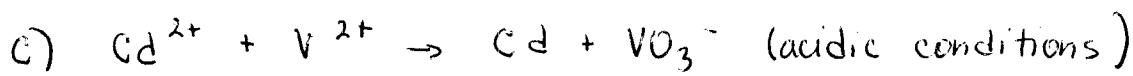
UNIT 4 - Electrochemistry

- ① a) Ba +2 ; H -1
 b) Al +3 ; C -4
 c) K +1 ; C +2 ; N -3
 d) Li +1 ; N +3 ; O -2
 e) N -3 ; H +1 ; C +3 ; O -2
 f) S 0
 g) As +3 ; O -2
 h) V +5 ; O -2
 i) Xe +6 ; O -2 ; F -1
 j) S +2.5 ; O -2
- ② a) O_2 is the oxidizing agent, C_6H_6 is the reducing agent
 b) not a redox reaction
 c) I_2 is the oxidizing agent, H_2 is the reducing agent
 d) $KMnO_4$ is the oxidizing agent, $CuCl$ is the reducing agent
- ③ a) Ca undergoes oxidation, Ag^+ undergoes reduction
 b) not a redox reaction
 c) Mn^{2+} undergoes oxidation, BiO_3^- undergoes reduction
- ④ a) oxidation number of vanadium is +5 in.
 V_2O_5 , VO_2^+ , VO_3^- , VO_4^{3-} , $V_3O_9^{3-}$
 and +4 in VO_2 , VO^{2+}
 b) This reaction is not a redox reaction because the oxidation #'s do not change

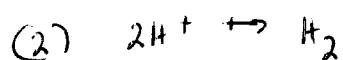
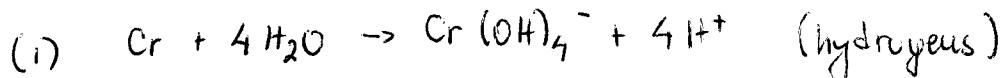
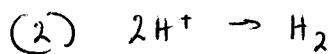
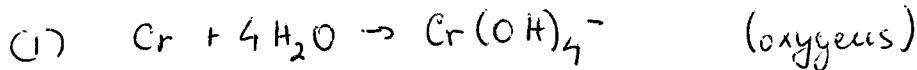
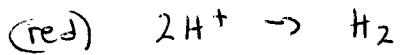
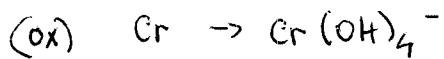
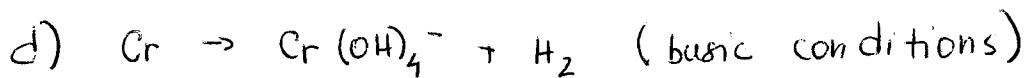
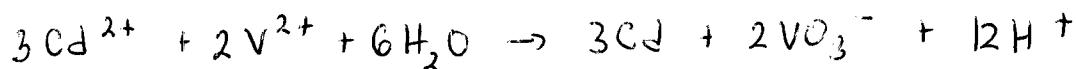
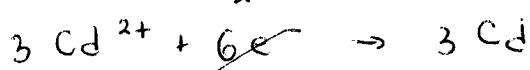
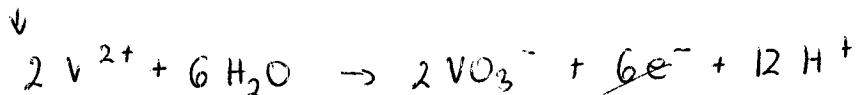


use the LCM for electrons

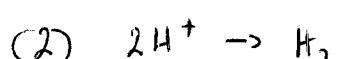




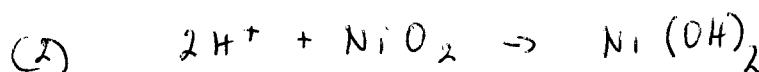
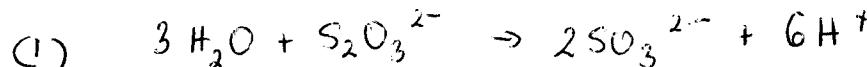
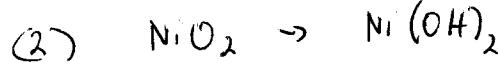
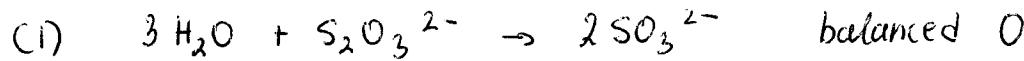
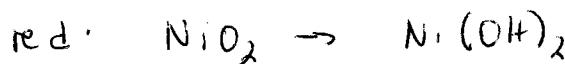
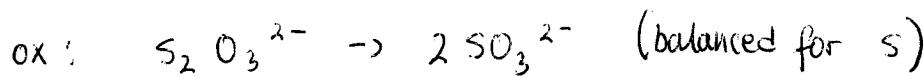
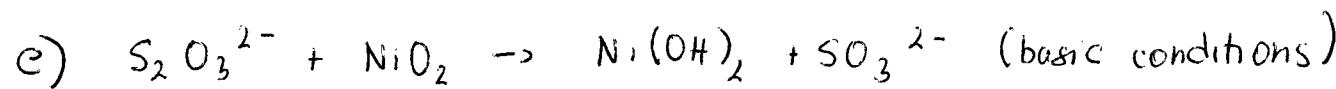
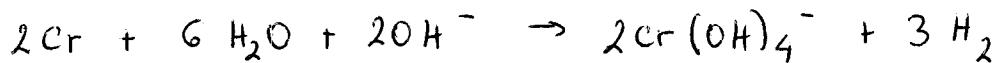
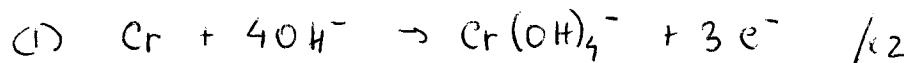
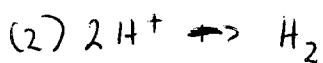
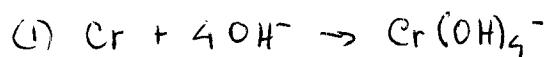
LCM



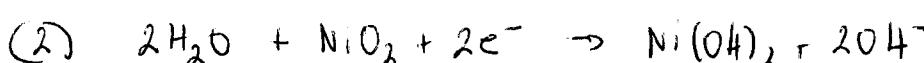
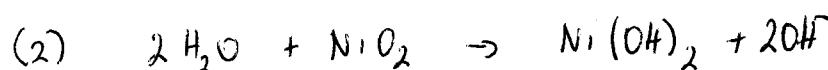
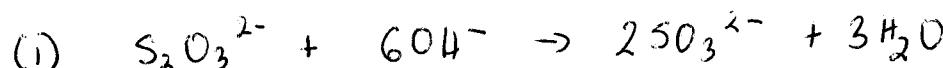
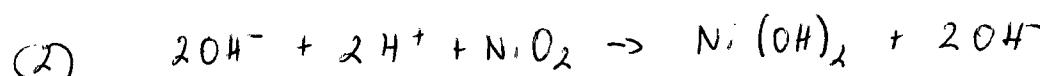
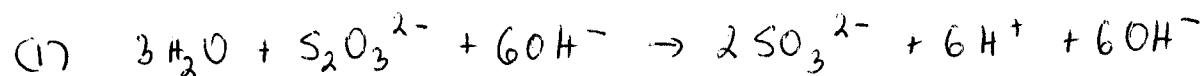
neutralize with OH^-



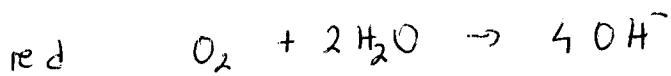
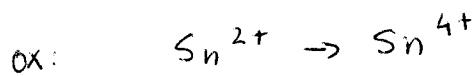
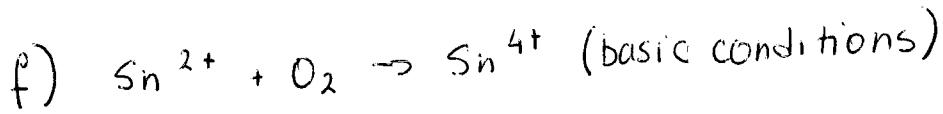
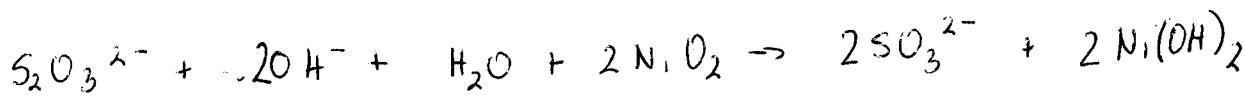
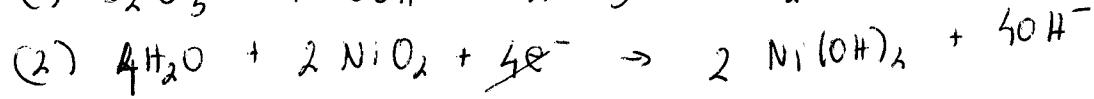
water irrelevant



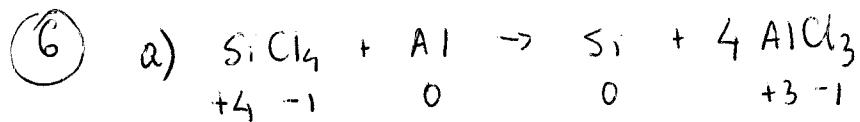
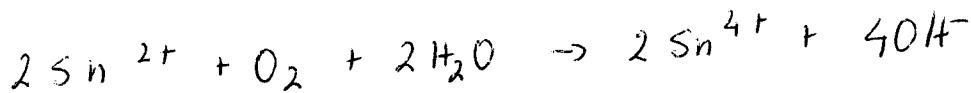
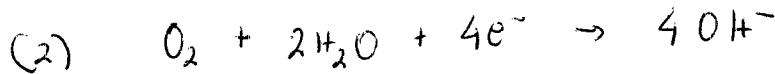
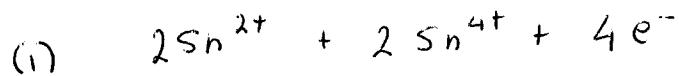
neutralize



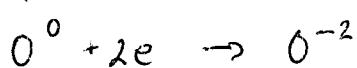
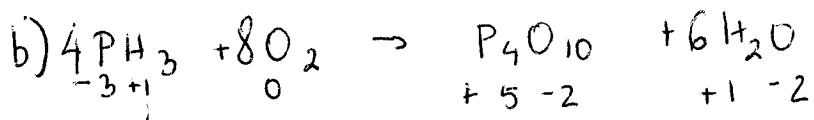
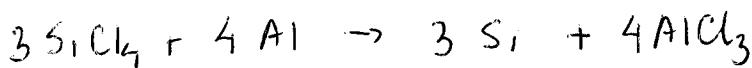
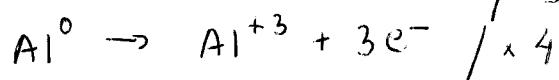
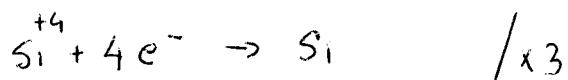
LCM



- atoms, oxygens and hydrogens are balanced
- just balance charges and use LCM

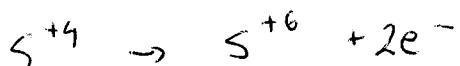
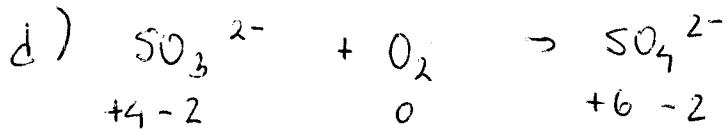
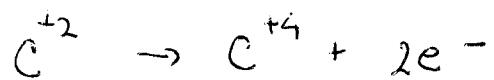
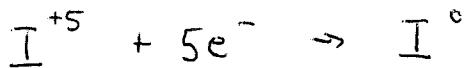
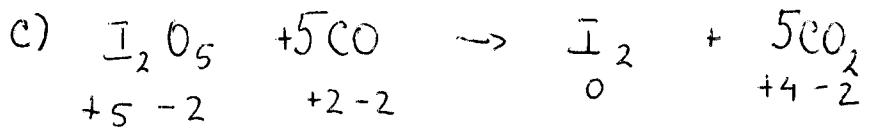


+4 -1 0 0 +3 -1

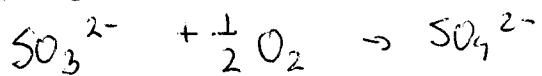


the ratio is 8:2 or 4:1

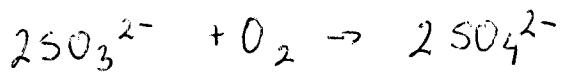
∴ For 4P ⇒ 16 O



balance O



or

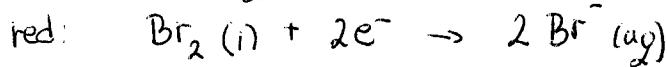
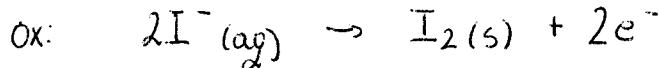


(7)

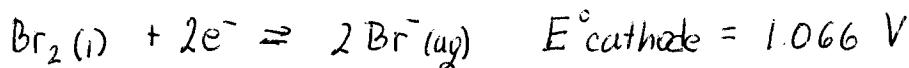
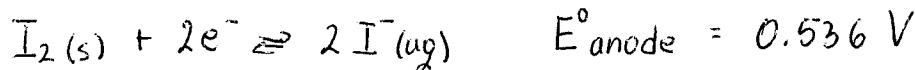


$$E^\circ_{\text{cell}} = ?$$

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$



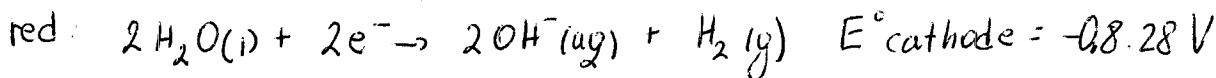
look into the table of standard reduction potentials



$$E^\circ_{\text{cell}} = 1.066 \text{ V} - 0.536 \text{ V}$$

$$= 0.530 \text{ V}$$

(8)

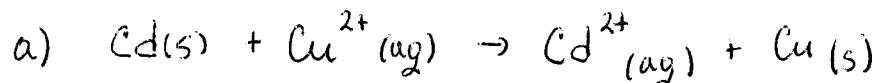


$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

$$= -0.828 \text{ V} - (-2.711 \text{ V})$$

$$= 1.883 \text{ V}$$

(9)



2 half reactions

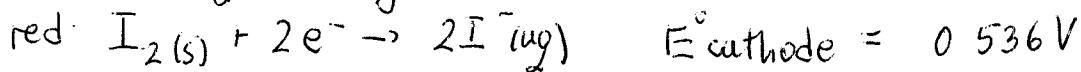
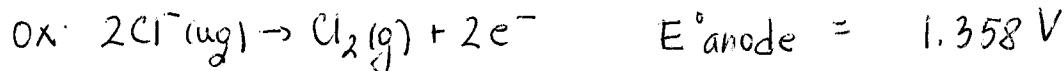
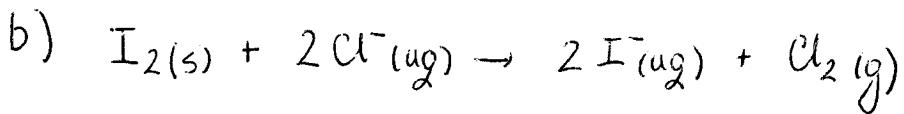


$$E^\circ_{\text{cell}} = 0.342 \text{ V} - (-0.403 \text{ V})$$

$$= 0.745 \text{ V}$$

The E°_{cell} is positive, so the reaction is spontaneous

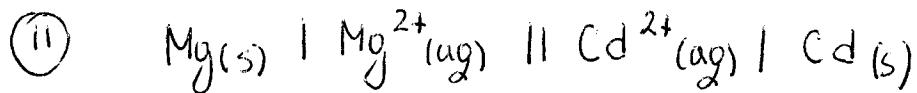
(43)



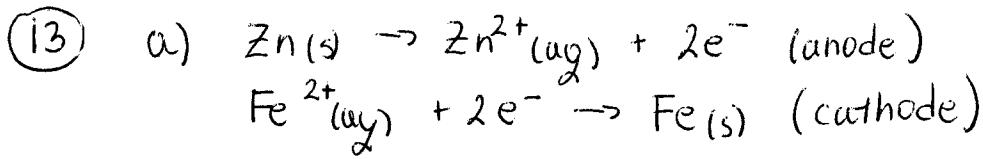
$$E^\circ_{\text{cell}} = 0.536 V - 1.358 V \\ = -0.822 V$$

The $E^\circ_{\text{cell}} < 0$, so the reaction is non-spontaneous under standard conditions.

- (10) a) Electrodes are the conductors that carry e^- into and out of the cell. Oxidation and reduction occur at the electrodes.
 b) Electrolytes are substances that dissolve in water to form ions that can move and conduct electricity.
 c) The external voltage is a source of electricity that is included in the external circuit of an electrolytic cell.

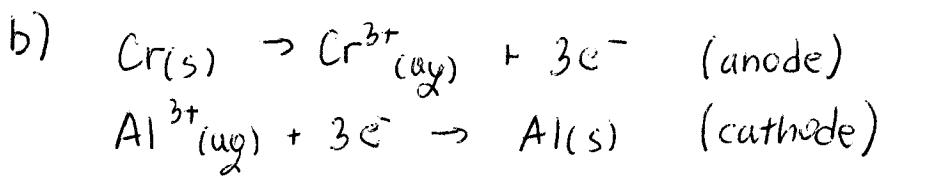


- (12) The hydrogen electrode is defined as the reference electrode against which other reduction potentials are measured. The reduction potential of the standard hydrogen electrode is assigned a value of 0.00 V.

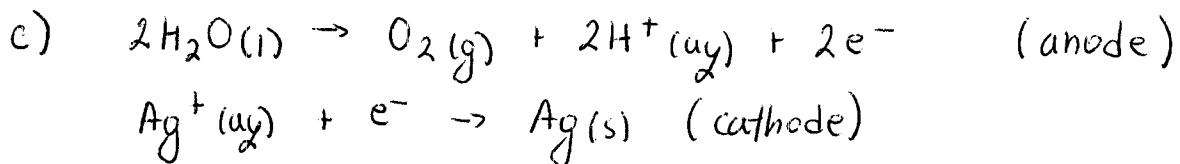


$$E^\circ_{\text{cell}} = -0.447 V - (-0.762 V) \\ = +0.315 V$$

Spontaneous



$$\begin{aligned}E^\circ_{\text{cell}} &= -1.662 \text{ V} - (-0.744 \text{ V}) \\&= -0.918 \quad (\text{non-spontaneous})\end{aligned}$$



$$\begin{aligned}E^\circ_{\text{cell}} &= +0.800 \text{ V} - 0.695 \text{ V} \\&= +0.105 \text{ V} \quad (\text{spontaneous})\end{aligned}$$

UNIT 5 - STRUCTURE AND PROPERTIES

①

Rutherford's nuclear model successfully accounted for the observations of α particle scattering, but it raised questions. If the e^- were circling the nucleus, then classical physics predicted that it would give off energy, resulting in the electron spiralling into the nucleus. However, atoms did not collapse, and neither did they give off a continuous spectrum. For example, the atomic spectrum of H appeared as lines rather than continuous smear of colour. Restrictions had to be placed to account for this. Bohr and Max Planck introduced the idea that the e^- in an atom can only have certain energies - the energies are quantized.

②

- a) Planck proposed that matter, at the atomic level, could absorb or emit only discrete quantities of energy. The energy of an atom was quantized
- b) De Broglie proposed that matter had wave-like properties
- c) Einstein proposed that light was also quantized and had particle-like properties. The quanta of light were later called photons
- d) Heisenberg showed that it was not possible to know both a particle's position and its momentum precisely. He and Schrödinger are credited with introducing quantum mechanics

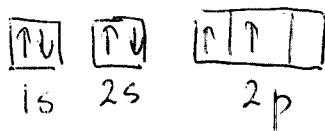
e) Schrödinger used math and stats to combine de Broglie's idea of matter waves and Einstein's idea of quantized energy particles (photons). Schrödinger's ideas, together with the Heisenberg's uncertainty principle, led to the description of atomic particles in terms of wave equations

③ Pauli's exclusion principle restricted the # of e^- in an orbital to be no more than 2. Thus, the max # of e^- is 2 for an s type orbital, 6 for a p type, 10 for a d type and 14 for an f type. According to Hund's rule, when e^- are added to a p, d or f type orbital, e^- of the same spin are added separately to orbitals with the same E first, before any pairing of e^- occurs. Thus, when writing e^- configuration of the first 3 e^- with $l=1$ and $m_l = 0, +1, -1$ all three e^- have $m_s = +\frac{1}{2}$

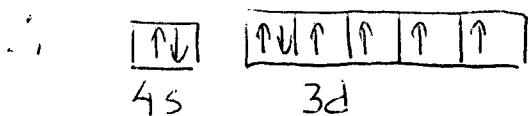
④ The electron is in the p orbital ($i=1$) of the 3rd energy level ($n=3$) \therefore 3p orbital

⑤ The e^- configuration for V is $[Ar] 4s^2 3d^3$. Therefore diagram (c) is the correct orbital diagram. According to the aufbau principle, the 4s orbital fills first, before the 3d orbital. When the 4s is filled, the 3 e^- fill the 3d following Hund's rule. (no pairing).

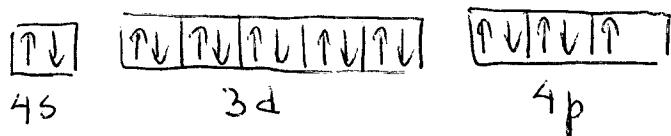
⑥ a) The e^- configuration for C is $1s^2 2s^2 2p^2$
 $2p e^-$ both have the same spin and should be in diff. orbitals



b) The e^- configuration for Fe is $[Ar] 3d^6 4s^2$
 $3d$ fills up before $4p$



c) Br: $[Ar] 3d^{10} 4s^2 4p^5$



- ⑦ a) Mg $1s^2 2s^2 2p^6 3s^2$
 b) Cl $1s^2 2s^2 2p^6 3s^2 3p^5$
 c) Mn $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
 d) Y $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$

⑧ a) $5s^1$
 period # = 5
 1 valence e^- \therefore Rb

b) $4s^2 3d^2$
 period # 4 \therefore Ti

c) $3s^2$
 period # = 3
 full s orbital \therefore Mg

d) $4s^2 3d^{10} 4p^3$
 period # 4
 full d, 3rd in p \therefore As

(9) $n = 1, 2, 3 \dots n$

$$l = 0, \pm 1, \pm 2, \pm 3 \dots \pm (n-1)$$

$$m_l = 0, \pm 1, \pm 2, \pm 3, \dots \pm l$$

If $l = 1 \quad l = 0$

Thus there is only one type of orbital, s, in period 1

(10) All the halogen halides are polar. They experience dispersion forces as well as dipole-dipole forces.

The dispersion forces are greatest in HI and smallest in HF, because the HI molecule is the largest and contains most electrons. ΔEN is greatest in HF and smallest in HI, so the dipole-dipole forces are greatest in HF and smallest in HI.

However, ΔEN is small for the halogens, so the difference in the strength of the dipole-dipole forces is not as significant as the difference in the strength of the dispersion forces.

Therefore, the bp. should ↑ from HF to HI.

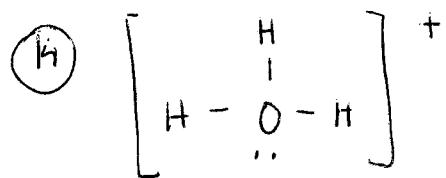
In HF, though, the relative sizes of the H atom and F atom allows hydrogen bonding to occur in this molecule. H bonding does not occur in the other hydrogen halides. As a result, HF has the strongest intermolecular forces and its bp is higher than the bp of other hydrogen halides.

(11) An induced dipole exists when a non-polar molecule comes close to an ion or a polar molecule. As soon as the ion or polar molecule moves away, the induced dipole disappears. A permanent dipole is produced by the difference in the

electronegativities of the atoms within a molecule. The dipole does not disappear, and its existence is independent of the presence of other molecules.

- (12) a) dispersion and dipole-dipole
b) ionic bond
c) metallic bond
d) dispersion forces

(13) H_2O and NH_3 have the same number of e^- in their molecules. ΔEN is greater for O-H (1.24) than for N-H (0.84). Therefore, the O-H bond is more polar and forms stronger hydrogen bonds. Thus H-bonding is stronger in H_2O than NH_3 .

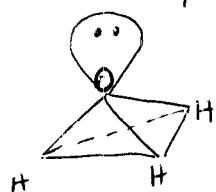


4 electron groups around the central O atom

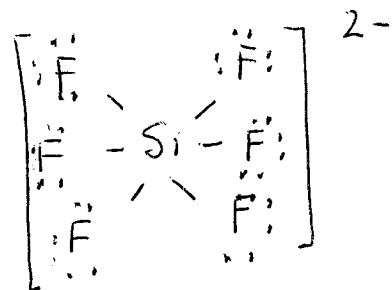
3 bonding pairs, 1 lone pair

tetrahedral ; trigonal pyramidal

(AX_3E)

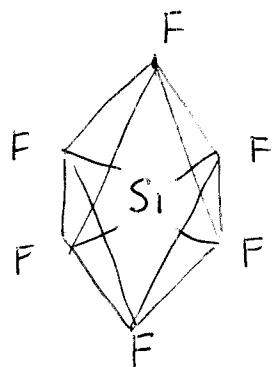


(15)



6 bonding pairs, 0 lone pairs
total of 6 electron groups around
the central atom

octahedral shape AX_6

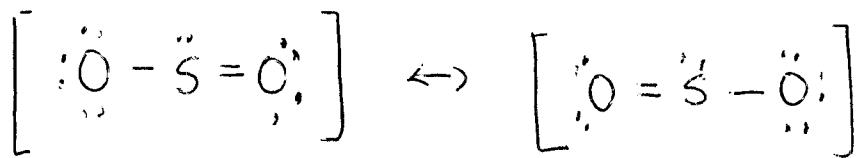


(16) a) HCN

$\text{H}-\text{C}\equiv\text{N}$; (Lewis structure)

2 bonding pairs (triple bond counts as one group)

LINEAR

 $\boxed{\text{AX}_2}$ b) SO_2  $\boxed{\text{AX}_2\text{E}}$

Central atom, S, 2 BPs 1 LP

ANGULAR (BENT, V-shaped)

(51)

c) SO_3

$$\begin{aligned} \text{total # of valence } e^- : & 1\text{S atom} \times 6e^- + 3\text{O atoms} \times 6e^- \\ & = 24e^- \end{aligned}$$

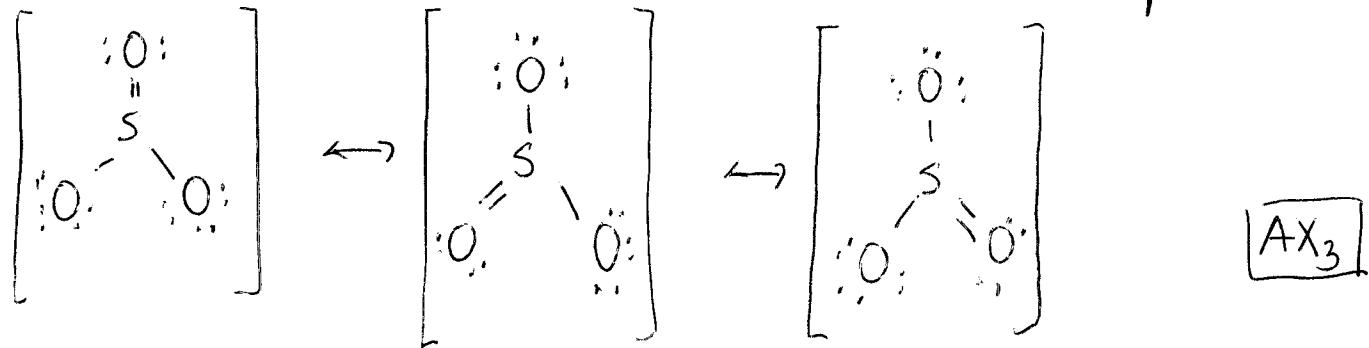
$$\begin{aligned} \text{total # of } e^- \text{ needed for noble gas configuration} \\ & = 4 \text{ atoms} \times 8e^- \\ & = 32e^- \end{aligned}$$

e^- used in bonding:

$$= 32e^- - 24e^-$$

= $8e^-$ or 4 covalent bonds

$$\begin{aligned} \# \text{ of non-bonding } e^- & = 24e^- - 8e^- \\ & = 16e^- \therefore 8 \text{ lone pairs} \end{aligned}$$



$3e^-$ groups around central atom 3 BPs

TRIGONAL PLANAR

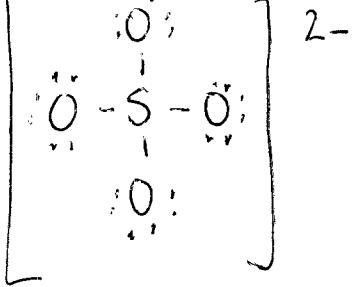
d) SO_4^{2-}

$$\begin{aligned} \text{total # valence } e^- : & 1\text{S atom} \times 6e^- + 4\text{O atoms} \times 6e^- + 2e^- \\ & = 32e^- \end{aligned}$$

$$\begin{aligned} \text{total } e^- \text{ needed} & = 5 \text{ atoms} \times 8e^- \\ & = 40e^- \end{aligned}$$

$$40e^- - 32e^- = 8e^- \quad 4 \text{ covalent bonds}$$

$$32e^- - 8e^- = 24e^- \quad 12 \text{ lone pairs}$$



4 e⁻ groups around central atom
4 BPs

$\boxed{AX_4}$

TETRAHEDRAL

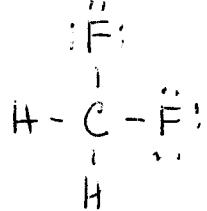
(17) a) CH₂F₂

$$\begin{aligned} \# \text{ of valence } e^- &: 1C \times 4e^- + 2H \times 1e^- + 2F \times 7e^- \\ &= 20e^- \end{aligned}$$

$$\begin{aligned} \# \text{ of } e^- \text{ needed} &= 3 \times 8e^- + 2 \times 2e^- \\ &= 28e^- \end{aligned}$$

$$\begin{aligned} e^- \text{ used} &= 28e^- - 20e^- \\ &= 8e^- \quad 4 \text{ covalent bonds} \end{aligned}$$

$$20e^- - 8 \text{ bonding } e^- = 12e^- \quad 6 \text{ lone pairs}$$



4 electron groups around central atom
4 BPs

TETRAHEDRAL

b) AsCl₅

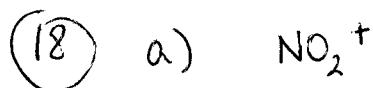
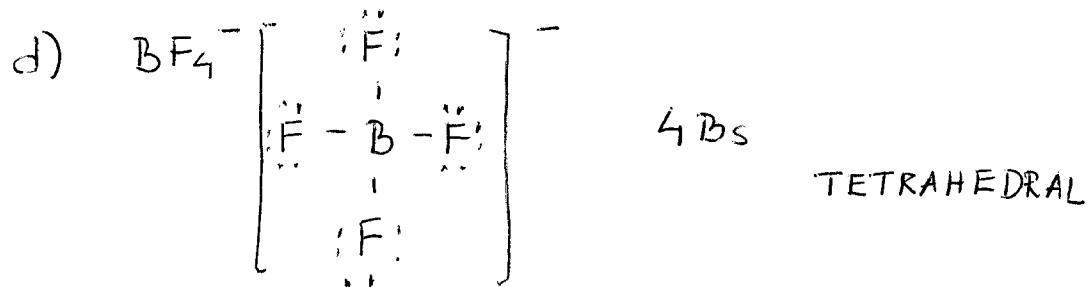
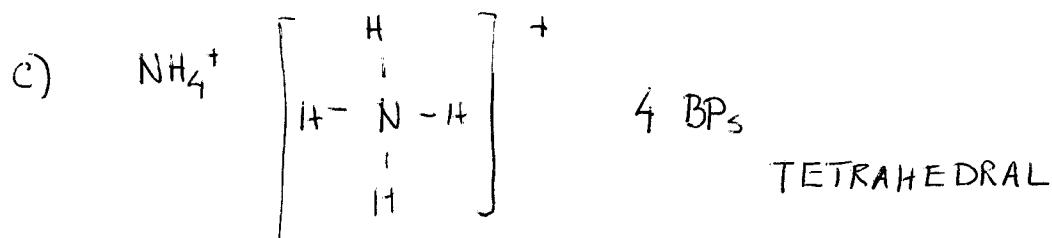
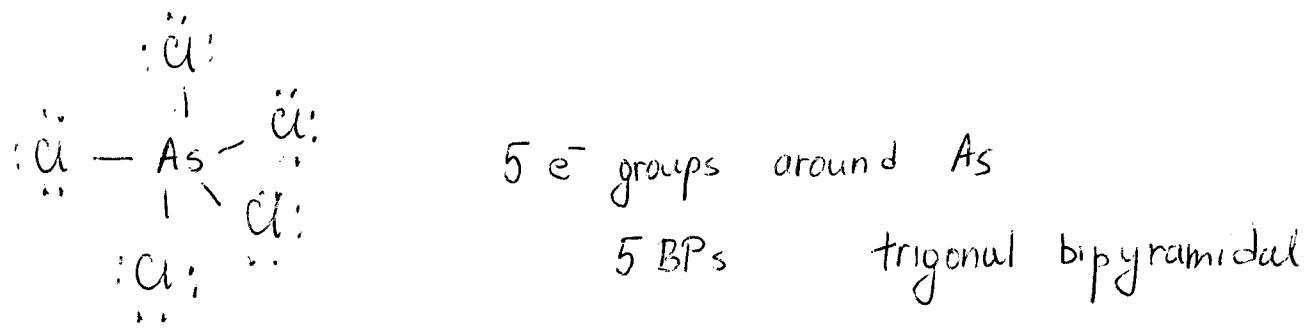
$$\begin{aligned} \# \text{ of valence } e^- &= 1As \times 5e^- + 5Cl \times 7e^- \\ &= 40e^- \end{aligned}$$

$$\begin{aligned} \# \text{ of } e^- \text{ needed} &= 6 \times 8e^- \\ &= 48e^- \end{aligned}$$

$$e^- \text{ used} = 48 - 40 = 8e^- \quad 4 \text{ covalent bonds}$$

however 10e⁻ are needed, meaning there is
an expanded octet

(53)



$$\begin{aligned}
 \# \text{ of valence } e^- &= 1N \times 5e^- + 2O \times 6e^- - 1e^- \\
 &= 16e^-
 \end{aligned}$$

$$\begin{aligned}
 \# \text{ of } e^- \text{ needed} &= 3 \times 8 e^- \\
 &= 24 e^-
 \end{aligned}$$

$$24 e^- - 16 e^- = 8 e^- \quad 4 \text{ covalent bonds}$$

$$\begin{aligned}
 \text{nonbonding } e^- &= 16 e^- - 8 e^- \\
 &= 8 e^- \quad 4 \text{ lone pairs}
 \end{aligned}$$



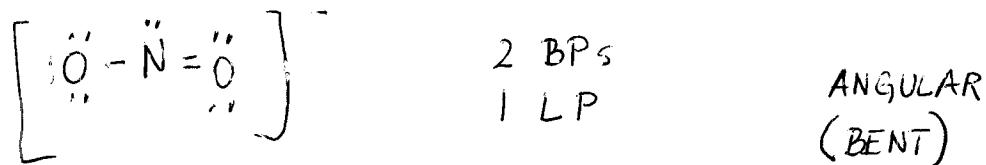


$$\begin{aligned}\#\text{ of valence } e^- &= 1\text{N} \times 5e^- + 2\text{O} \times 6e^- + 1e^- \\ &= 18e^-\end{aligned}$$

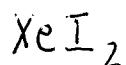
$$\begin{aligned}\#\text{ of } e^- \text{ needed} &= 3 \times 8e^- \\ &= 24e^-\end{aligned}$$

$$\begin{aligned}\text{used in bonding} &= 24e^- - 18e^- \\ &= 6e^- \quad 3 \text{ covalent bonds}\end{aligned}$$

$$\text{non-bonding } e^- = 18e^- - 6e^- = 12e^- \quad 6 \text{ lone pairs}$$



(19)



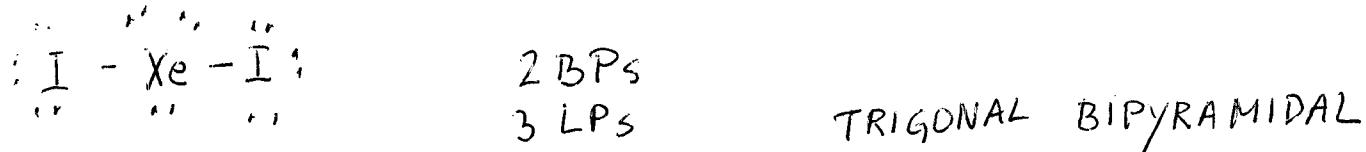
a) # of valence $e^- = 1 \text{ Xe atom} \times 8e^- + 2\text{I} \times 7e^-$
 $= 22e^-$

$$\begin{aligned}\#\text{ of } e^- \text{ needed} &= 3 \times 8e^- \\ &= 24e^-\end{aligned}$$

$$\begin{aligned}\text{used in bonding} &= 24 - 22 \\ &= 2e^-\end{aligned}$$

* 4 are needed to bond 2 I atoms, meaning expanded octet

$$\begin{aligned}\text{non bonding } e^- &= 22e^- - 4e^- \\ &= 18e^- \quad 9 \text{ lone pairs}\end{aligned}$$





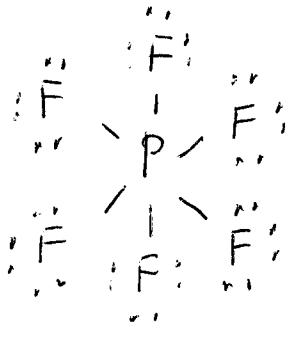
$$\begin{aligned}\#\text{ of valence } e^- &= \text{IP} \times 5e^- + 6F \times 7e^- + 1e^- \\ &= 48e^-\end{aligned}$$

$$\begin{aligned}\#\text{ of } e^- \text{ needed} &= 7 \times 8e^- \\ &= 56e^-\end{aligned}$$

$$\begin{aligned}\#\text{ of bonding } e^- &= 56 - 48 \\ &= 8e^- \text{ 4 covalent bonds}\end{aligned}$$

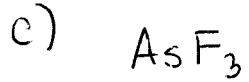
6 are needed \rightarrow expanded octet
(12e⁻)

$$\begin{aligned}\#\text{ of non-bonding } e^- &= 48e^- - 12e^- \text{ bonding } e^- \\ &= 36e^- \text{ 18 lone pairs}\end{aligned}$$



6 BPs on P

OCTAHEDRAL



$$\begin{aligned}\#\text{ of valence } e^- &= 1\text{As} \times 5e^- + 3F \times 7e^- \\ &= 26e^-\end{aligned}$$

$$\begin{aligned}\#\text{ of } e^- \text{ needed} &= 4 \times 8e^- \\ &= 32e^-\end{aligned}$$

$$\begin{aligned}\#\text{ of bonding } e^- &= (32 - 26)e^- \\ &= 6e^- \text{ 3 covalent bonds}\end{aligned}$$

$$\begin{aligned}\#\text{ of non bonding } e^- &= 26e^- - 6e^- \\ &= 20e^- \text{ 10 lone pairs}\end{aligned}$$



3 BPs
1 LP

TRIGONAL PYRAMIDAL

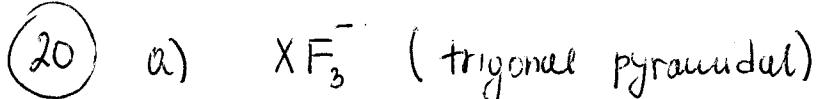
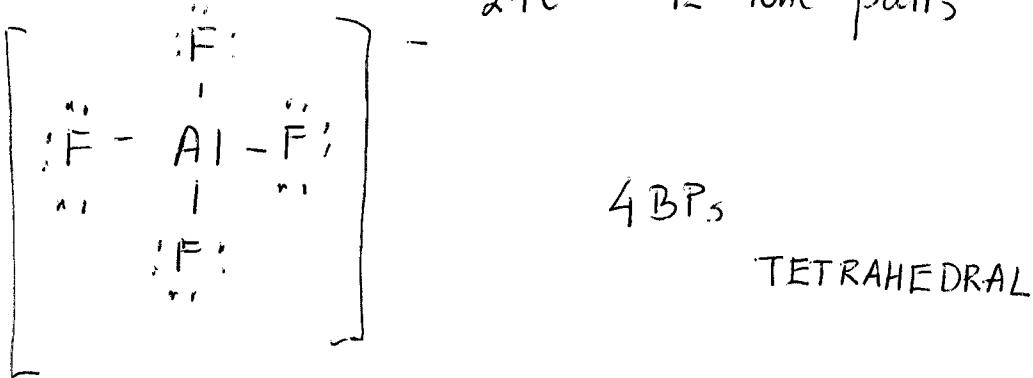


$$\begin{aligned}\# \text{ of valence } e^- &= |\text{AL} \times 3e^- + 4\text{F} \times 7e^- + 1e^- \\ &= 32e^-\end{aligned}$$

$$\begin{aligned}\# \text{ of } e^- \text{ needed} &= 5 \times 8e^- \\ &= 40e^-\end{aligned}$$

$$\begin{aligned}\# \text{ of bonding } e^- &= 40 - 32 \\ &= 8e^- \quad 4 \text{ covalent bonds}\end{aligned}$$

$$\begin{aligned}\# \text{ of non-bonding } e^- &= 32 - 8 \\ &= 24e^- \quad 12 \text{ lone pairs}\end{aligned}$$



VSEPR notation is AX_3E

3 BPs 1 LP

number of e^- contributed by central atom $8e^-$ ($4 \text{ pairs} \times 2e^-$)
 $-3e^-$ (one e^- for each F) + $1e^-$ for charge = $6e^-$

\therefore central atoms O, S, Se etc.

b) XF_4^+ (tetrahedral)

VSEPR AX_4

4 BPs 8 valence e^-

of e^- on central atom

$8e^- - 4e^-$ (one for each F) + 1 e^- for charge

= 5 e^-

central atom group 15: N, P, As . . .

c)

XF_3 (T-shaped)

VSEPR is AX_3E_2

3 BPs 2 LPs \Rightarrow 10 valence e^-

on central atom $10e^- - 3e^-$ (one for each F)

= 7 e^-

central atom group 17: Cl, Br, I . . .

*

DON'T FORGET TO STUDY ALL THE OTHER
COMMON SHAPES