

## Sulphur and its compounds

- Frasch process*
  - Hot compressed air*
  - Monoclinic / prismatic sulphur / beta sulphur*  
*Rhombic/octahedral sulphur / alpha sulphur*
- RFM of  $H_2SO_3 = 98$  (no units)*  
*Number of moles of  $H_2SO_4 = \frac{1.8}{98}$*   
 $= 0.01837 \text{ moles}$   
*Molarity of  $H_2SO_4 = \frac{0.01837 \times 1000}{1}$*   
 $= 18.37M$                       P ½
  - Apply formular;  $M \text{ conc.} \times \text{Vol conc.} = M \text{dil.} \times V \text{dil.}$*   
 $18.37 \times V \text{ conc.} = 0.2 \times 500$                        $V \text{conc.} = \frac{0.2 \times 500}{18.37}$   
 $= 5.44 \text{ cm}^3 \text{ of conc. } H_2SO_4$
- By dissolving in water*
  - Manufacture of fertilizers*
  - Manufacture of detergents*
  - Cleaning of metal surfaces*
  - As an electrolyte in car batteries*
  - In refining of petroleum*
  - Manufacture of synthetic fibre (e.g. rayon)*
  - Manufactures of paints, dyes and explosives (award 1mk any one)*
- Chlorine bleaches permanently by oxidation P1 while sulphur (IV) oxide bleaches temporary by reduction. P1*
- Weak acid P1*
  - Has few free  $H^+$  (Hydrogen) ions*
- Vanadium (v) oxide*                       $V_2O_5$      $\ddot{O} \frac{1}{2}$
  - $2SO_2(g) + O_2(g) \xrightarrow{\quad\quad\quad} 2SO_3(g)$      $\ddot{O} \frac{1}{2}$
  - $SO_3(g) + H_2SO_4(l) \xrightarrow{\quad\quad\quad} H_2S_2O_7(l)$   
  
 $H_2S_2O_7(l) + H_2O(l) \xrightarrow{\quad\quad\quad} H_2SO_4(l)$

*Student must explain*

*Explanation 1 mark*

7. – Concentrated sulphuric acid oxidizes copper turnings to copper(II) oxide black solid,  $\text{SO}_2$  gas and water. <sup>1/2 mk</sup>
- Then copper (II) oxidizes excess conc. sulphuric acid to produce copper (II) sulphate mk
  - Which is dehydrated by conc. Sulphuric acid to anhydrous copper(II) sulphate white solid <sup>1 1/2</sup>  
Which dissolves in water to produce blue solution
8. a) Method of collection is wrong. <sup>1/2</sup> Should be collected by downward delivery/upward displacement of air <sup>1/2</sup> since the gas is denser than air.
- b)  $\text{Na}_2\text{SO}_3(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$  <sup>1</sup>

c) By passing it through calcium hydroxide in which the gas dissolves. ✓<sup>1</sup>

9. a) Dirty grey solids are formed. ✓<sup>1</sup>



c) Iron powder has high surface area hence the reaction is none vigorous than iron fillings with low surface area.

10. a) a sulphate e.g. sodium sulphate ✓<sup>1</sup>

b) moist blue litmus paper turns to red ✓<sup>1/2</sup> then after some minutes to white ✓<sup>1/2</sup> .it is bleached by sulphur(iv)oxide



11. (a) - Flexible ✓<sup>1</sup>  
 - Strong and tough ✓<sup>1</sup>  
 - Non-sticky ✓<sup>1</sup> (any two)

(b) Molten sulphur would have lost heat to the surrounding ✓<sup>1/2</sup> hence solidify/ in the middle pipe ✓<sup>1/2</sup> sulphur cannot solidify since hot air in the inner pipe and hot water in the outer pipe mountains high temperature.

12. (a) It dissolves in water releasing ✓<sup>1</sup> a lot of heat which boils the acid which can easily be spilt to the body. ✓<sup>1</sup> (2 mks)

(b) - It is used in manufacture ✓<sup>1</sup> of batteries/acid accumulators. Any 3  
 - Manufacture of soap, plastics, detergents. one

13. (a) Deposits of a yellow solid; and droplets of colourless liquid;



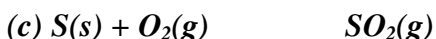
(c) Oxidizing agent

14. (a) A – takes in hot compressed air to force out molten sulphur to the surface.

B - takes out molten sulphur.

C – takes in super heated water to melt the sulphur.

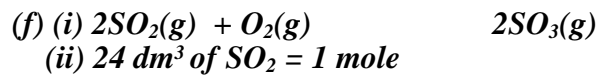
(b) Rhombic, Monoclinic



(d) Iron (II) sulphide.

(e) – Vulcanization of rubber.

- *Making chemicals*
- *Manufacture of matches and fire works.*



$$6.0 \text{ dm}^3 \frac{1 \text{ mol} \times 6 \text{ dm}^3}{24 \text{ dm}^3} \text{ P}^{1/2} = 0.25 \text{ mole P}^{1/2}$$

*From the equation :-*

$$\text{Moles of } O_2 \text{ used} = \frac{0.25}{2} P^{1/2} = 0.125 \text{ moles } P^{1/2}$$

(iii) 1 mole of  $O_2 = 0.125$

$$\begin{aligned} 0.25 \text{ mole} &= \frac{24 \text{ dm}^3 \times 0.125 \text{ mol}}{1 \text{ mol}} P^1 \\ &= 3. \text{ dm}^3 P^1 \end{aligned}$$

15. i) X – Rhombic  $\sqrt{1/2}$

Y – Monoclinic  $\sqrt{1/2}$

ii) I) Mg has a higher  $\sqrt{1}$   $\sqrt{1}$  affinity for combined oxygen than S.

II) Add  $\sqrt{1}$  dilute nitric acid to the mixture. It reacts with  $MgO \sqrt{1}$  to form  $Mg(NO_3)_2$

Filter  $\sqrt{1}$  to obtain S as residue.

16. (a) (i) – Rhombic sulphur ( $1/2$  mk)

(ii) Sulphur is heated until it boils. The boiling liquid sulphur is then poured into a beaker containing water to form plastic sulphur ( $1/2$  mk)

(a)

(i) – sulphur ( $1/2$  mk)

- Iron (II) Sulphide (Iron pyrites)

- Zinc sulphide (Zinc blend)

- Dust or Arsenic compounds ( $1/2$  mk)

(c) – Avoid poisoning of the catalyst (Avoid destruction of catalytic properties by impurities)

(d)  $2S_{(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$

(e) (I) – Vanadinim (V) Oxide ( $1/2$  mk)

(II) - Heat incoming air ( $SO_2$  & Air)

- Cools the  $SO_3$

(III) - The reaction between  $SO_2$  and water is highly exothermic which makes the solution boil to form a mist of dilute sulphuric (VI) acid which pollutes the environment

(g) I. –  $SO_2$

II- Un reacted  $SO_2$  is recycled

o Absorbed by  $Ca(OH)_2$  in tall chimneys

- Passed over hot carbon (IV) Oxide and sulphur which is recycled and Carbon (IV) Oxide released to the environment

(h) Manufacture of fertilizers

17. a) (i)

(ii) *I ion II sulphide or copper II Sulphur*  
*II anhydrous Calcium Chloride* (zero of Calcium chloride)  
*III Fe s<sub>(l)</sub> + Hcl<sub>(aq)</sub> Fecl<sub>2(aq)</sub> + H<sub>2</sub>s*

b)  $Fe^{3+}$  is reduced or  $Fe^{2+}$  or  $Fe^{2+}_{(aq)}$  ions are formed

$H_2S$  is oxidized to sulphur or sulphur is formed.

- c) (i) Vanadium V oxide or platinised asbestos  
 (ii) I. The yield of  $SO_3$  increases because an increase in pressure favours the forward reaction since a smaller number of  $SO_3$  molecules are present.  
 II. The yield of  $SO_3$  is the same because a catalyst only speeds the rate at which equilibrium is reached.  
 (iii) Exothermic reaction occurs. When dissolved in water produces acid spray (fumes) causing pollution.

- 18 (a) (i) Red-brown fumes  
 (ii) It is not an oxidizing agent  
 (iii)  $S_{(s)} + 6HNO_{3(l)} \rightarrow 2H_2O_{(l)} + 6NO_{2(g)} + H_2SO_{4(l)}$   
 (iv) Neutralization  
 (v) Sulphuric acid  
 (vi) Forms acid rain / plant + yellowing corrodes metallic and stone works

19. a) i) They are different physical/ structural forms of an element

ii) Transition temperature

b) i) X - Diluter

Y- Heat exchanger

Z- Roaster/ Burner

ii) Catalyst- Vanadium (v) Oxide,  $V_2O_5$

Temperature – 450°C

Pressure – 1 atmosphere

iii) I - They are purified not to poison the catalyst

II - The reaction in the converter/ production of sulphur (vi) Oxide is exothermic/ heat is produced. Chamber Y is used to ensure temperature does not rise above 450°C

iv) Step 2:  $2S_{2(g)} + O_{2(g)} \xrightarrow{\quad\quad\quad} 2SO_{3(g)}$  0 1 mark Step

3:  $SO_{3(g)} + H_2SO_{4(l)} \xrightarrow{\quad\quad\quad} H_2S_2O_7(l)$  0 1 mark Step 4:

$H_2S_2O_7(l) + H_2O_{(l)} \xrightarrow{\quad\quad\quad} 2H_2SO_{4(l)}$  0 1 mark

20. - Test tube L- Acidified  $KMnO_4$  changed from purple to colourless (it is decolourized) –  $SO_2$  is a reducing agent.

- Test tube K  $H^+/KMnO_4$  was not decoloured –  $SO_2$  was absorbed by ash solution hence did not reach the  $H^+/KMnO_4$ . P 1 P 1

21. a) Metal sulphide

b) Hydrogen sulphide is less soluble in warm water compared to cold water

22. *SO<sub>2</sub> form acidic when it dissolves in atmospheric moisture. The acidic rain lowers soil PH/ corrodes stone building*  
*No – disrupts the Ozone cycle hence causing depletion of Ozone layer which react with oxygen in the atmosphere to form NO<sub>2</sub> gas*
23. a) *The solution changed from brown/yellow **P**<sup>1/2</sup> to light/pale green **P**<sup>1/2</sup>*  
b) *2FeCl(aq) + H<sub>2</sub>S(g)                      2FeCl<sub>2</sub>(aq) + 2HCl(aq) + S(s) **P**1 mk*  
c) *Oxidation. **P**1 mk*



24. *Barium carbonate reacts with dilute sulphuric (VI) acid to form the insoluble Barium sulphate ( $BaSO_4$ ) which covers the reactant. Barium Carbonate preventing any contact between the acid and the Carbonate salt.  
Hence, the reaction is slow and stops after a very short time.*

