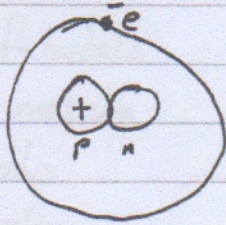


Advanced Chemistry of OME (ACOA5014)13/05/21

1. a)



p = proton (Positive)
 n = neutron (neutral)
 e = electron (negative)

(3)

- b) i) An electron can revolve around the nucleus in certain fixed orbits of defined energy without emitting energy
- ii) An electron can transition from a stationary orbit of higher energy to a lower energy and emits a ~~single~~ single photon with a specific / characteristic wavelength (1)
- iii) Only those orbits are allowed for which the angular momentum of the orbit is an integer multiple of $h/2\pi$
- c) When ~~energy~~ ~~is~~ to an electron moves from a higher energy level to a lower energy level ~~the atom~~ a photon is given off. Each atom ~~has different~~ gives off different frequency photons (3)
- d) In ~~the~~ decay flares emitting at a specific wavelength can fool a seeker of a MANPAD or similar system (1)

(8)

2. a) Hydrogen

Alkali metals

Alkali earth metals

Transition metals

Poor metals

Non metals

Noble gases

Rare earth metals

(1)

b) ~~At. no.~~ Mass number is the total number of protons & neutrons in ~~an~~ nucleus
Atomic number is the number of protons in a nucleus

(2)

d)

N: 3 Valence

O: 2

F: 1

Ne: 0

(3)

c) N: 5

O: 6

F: 7

Ne: 8

No of atoms outer shell

(4)

e) ~~the the~~ If the outer shell is full (as in Ne) then the material is inert. The higher the valence the less reactive a material is. eg: valence of 1 ^{more} reactive than valence 3

(4)

f) Carbon, Hydrogen, Oxygen, Nitrogen

Aluminium, Phosphorus, Magnesium, Strontium

(1)

15
=

3. a) Stability ~~is~~ refers to the likelihood of a material degrading over time. ~~the~~
 Little degrading = stable

(1)

b) The molecules in a material have different velocities. ~~the~~ the Boltzman distribution is the distribution of these velocities

(3)

$$P = e^{\frac{-E}{kT}}$$

c) Activation energy is the energy which needs to be added to allow a reaction to start

(1)

d) NC requires less energy to be added to the system for the decomposition reactions to start making it ~~be~~ more easily initiated

(2)

e) NC breaks down over time with each molecules giving off nitrate ~~date~~ groups, these can accelerate the rate of the remaining NC molecules breaking down. Stabilisers will react with these released nitrate groups and slow down the rate.

(3)

f) Every 10°C rate doubles 30°C difference

10 years $\rightarrow$ 5 $\rightarrow$ 2.5 $\rightarrow$ 1.25

1.25 years.

(4)

g) There is the possibility of autocatalytic decomposition as there isn't enough stabiliser to absorb the nitrate groups. This could lead to detonation

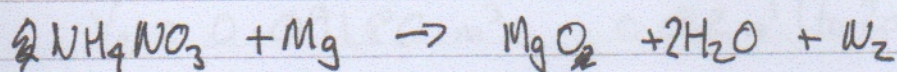
(15)

(1)

4. a) The enthalpy change of a reaction is independent of the route taken providing the initial and final states are the same.

(1)

b) AN & Mg



(3)

c)

X2

↓

$$-601 + (-242) = -843$$

$$-365 \text{ kJ mol}^{-1}$$

(2)

$$H_{\text{rxn}} = H_2 - H_1 \quad -843 - (-365) = \underline{\underline{-478 \text{ kJ mol}^{-1}}}$$

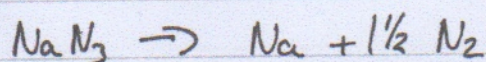
$$\text{d) } \begin{array}{l} 2N = 28 \\ 4H = 4 \\ 3O = 48 \end{array} \quad \frac{-478 \times 1000}{80} = 5975 \text{ kJ kg}^{-1} \text{ or } 5.975 \text{ kJ g}^{-1}$$

The heat of reaction per gram is almost ^{over} double that of 1g of TNT

(2)

(8)

5. a) BOg



(2)

$$\text{b) } 1 \text{ mol NaN}_3 = 65 \text{ g} \quad 130 = 2 \text{ mol} \therefore 3 \text{ mol N}_2 \quad 3 \times 14 = \underline{\underline{42 \text{ g}}}$$

(1)

$$\text{c) } 1 \text{ mol} = 22.4 \text{ L} \quad \therefore 3 \text{ mol} = 22.4 \times 3 = \underline{\underline{67.2 \text{ L}}}$$

(2)

6/7

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d) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$V_1 = 67.2 \text{ L or } 0.0672 \text{ m}^3$

$T_1 = 273.16 \text{ K}$

$V_2 =$

$T_2 = 373.16 \text{ K}$

$V_2 = 0.09180 \text{ m}^3 \quad 0.092 \text{ m}^3 \text{ (to 2 d.p.)}$

(2)

e) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$P_1 = 100,000 \text{ Pa}$

$T_1 = 273.16$

$P_2 =$

$T_2 = 373.16$

$P_2 = 136606.58 \text{ Pa or } 136.6 \text{ KPa}$

(2)

f) $pV = \frac{1}{2}mv^2$

$p = 136606 \text{ Pa}$

$V = 0.0672 \text{ m}^3$

$m = 0.5 \text{ kg}$

$v = ?$

$v = 191.623 \text{ ms}^{-1} \quad \text{or } 191.62 \text{ ms}^{-1} \text{ (to 2 d.p.)}$

(3)

g) There will be energy losses in the system through heat, Air resistance, friction etc

(2)

14

6. a) Should be cellulose nitrate

(1)

b) Sulphuric & nitric acid mixed

Added to cellulose

Material ~~is~~ pulped then washed to remove excess acid

Poached to remove unstable ~~impurities~~ impurities

Wringing

Mixing with ether & alcohol & ~~pressed~~ pressed

Granulated / extruded

Dried

(3)

c) It improves the efficiency of the reaction

d) Poaching removes unstable impurities which may accelerate decomposition and result in ignition

(2)

e) Low nitrogen is less than 12% nitrogen & high nitrogen is above 12%.

(1)

f) Single base: NC Small arms propellant

Double base: NC & NG Rocket motor propellant

Triple base: NC, NG & Nitroguanidine gun propellant

(6)

g) It can corrode the barrels x

Production of NG is dangerous x

h) because it is cheap, effective, relatively easy to make and relatively easy to ignite when required

(3)

16

7. a) Sensitivity: ~~The energy~~ How easily it will initiate in its design mode
Sensitivity: How easily it will initiate unintentionally

(2)

b) Mainly used in mining or ~~is~~ when shifting large amounts of earth/rocks eg: road cratering
It is relatively cheap, it ~~has~~ can be safely transported

(3)

c) ~~Oxidiser~~ AN: Oxidiser

NaNO_2 : Oxidiser

Water: To ~~be~~ suspend the particles in

Oil: Fuel

Al: Sensitiser & fuel

Sorbitan Sesquileate: Emulsifier

Glass balloons: Sensitiser

(7)

d) Microscopic droplets ~~and~~ of AN solution suspended in oil

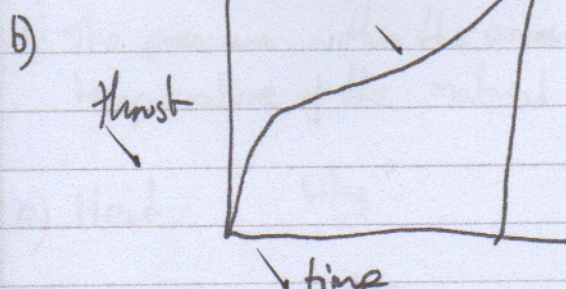
(2)

e) They get sensitise the material. Also provide voids which create hot spots ~~making~~
? geometry

(3)
17

8. a) By the grain material & its construction ~~By~~ By the design of the rocket motor body to control the pressure

(3)



(3)

c) Verkle's Law

$$r = \beta p^\alpha$$

r = burn rate (mm s^{-1})

β = burn rate coefficient (no units)

p = pressure (MPa)

α = pressure index (no units)

(4)

d) α : 0.9704 or 0.97 (to 2 d.p.)
 β : 0.4945 or 0.49 (to 2 d.p.)

How?

(11)

(1)

9. a) As the ^xdye burns it ~~is~~ is mixed with the burning fuel which creates the different coloured smoke

b) Pellets of pressed composition inside the flame body. The densities would need to be ~~some~~ consistent to ensure a consistent burn

(1)

c) Testing on the materials to ensure the time duration of smoke production & its brightness is as required. Ensure it is chemically compatible with other construction materials in the case. Test of the ease of initiation

d) The pressure within the container, the density the pellets are pressed at & the temp temperature of the material

(1)

e) Heat. Why?

f) To carry the ^{dye}~~smoke~~ particles to allow them to be seen

(1)

~~(3)~~

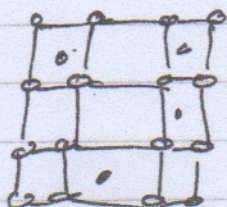
- g) Reaction 2 will produce a lower volume of gas as it produces Both reactions produce 12 moles of H_2O plus 12 moles of either CO or CO_2 as 1 mole (as STP) takes up 22.4L the volume of gas is the same, although producing CO is less favourable as it is toxic

(1)

(4)

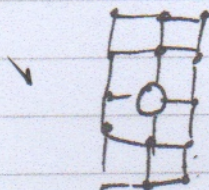
10. a) L = liquid. Both separately flowing
a = Cu dissolved in the Al lattice

(1)



$\alpha + \theta$: The Cu & Al are solid and not mixing

$\alpha + \theta$: Solid lumps of Cu in the Al



$\theta + L$: a mix of solid lumps of Cu in liquid Al

- b) Dislocations occur under strain. One row in a plane is moved rather than the whole plane. (2)

- c) The $\alpha + \theta$ phase has larger lumps of Cu in the lattice than α is the α phase. They interfere with the plane making dislocations harder to form or propagate through the material. This will make it stronger but less easy to mold.

(2)

- d) As the material needs to be ductile to form it and needs to be solid ~~the~~ forming it from and ~~hardening~~ treating it using Solid solution strengthening is the best option. This sits in the a area of the phase diagram

5