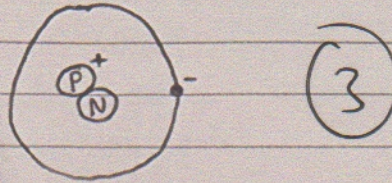


Advanced Chemistry Exam

Max Smith (1810364) 13/05/21

Question 1

a) Deuterium Atom



b) Bohr's Postulates

- An electron can revolve around the nucleus in certain fixed orbits of definite energy without emission of any radiant energy. Such orbits are called stationary orbits.
- An electron can make a transition from a stationary orbit of higher energy to a stationary orbit of lower energy and in so doing emits a single photon with a characteristic wavelength.
- Only those orbits are allowed for which the angular momentum of the orbit is an integer multiple of $h/2\pi$ where h is Planck's constant.

c) When hydrogen emits light, it is emitting a photon representative of the difference in electron shells.

d) Practical uses are in spectroscopy to accurately identify elements and molecules in a compound. Can also be used for lasers at a set frequency.

6

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Question 2

- a) Hydrogen Poor metals
Alkali metals Non metals
Alkali earth metals Noble gases
Transition metals Rare earth metals

(1)

- b) Atomic number is the number of protons in an element.
Mass number is the number of protons and neutrons in an element.

(2)

- c) Number of electrons in outer shell : Nitrogen : 5
Oxygen : 6
Fluorine : 7
Neon : 8

(4)

- d) Valency of nitrogen is 3 (either 3 from one atom or 1 from 3 atoms)
oxygen is 2
fluorine is 1
neon is 0 as full shell

(3)

- e) The lower the valence the more reactive the substance with the exception of noble gases which are non reactive. Generally LHS and RHS of periodic table are most reactive. Those nearer to the middle are less reactive. Neon = non reactive. Fluorine = very reactive. Reactivity decreases for oxygen and increases for nitrogen.

(4)

- f) Carbon Strontium Boron Copper
Hydrogen Phosphorus Aluminium Potassium
Nitrogen Sodium Magnesium Iron
Oxygen Magnesium Bismuth Barium

(1)

15
=

Question 3

a) Stability is the ability of an explosive to be stored with deterioration i.e. doesn't degrade through time. (1)

b) Boltzmann postulated that the number of molecules attaining to a specific velocity was related to temperature where

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

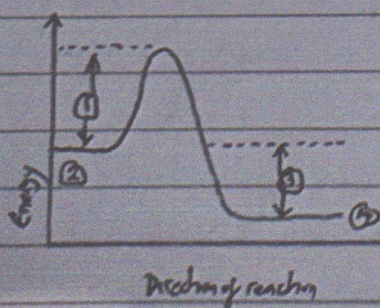
p = the fraction of molecules attaining energy E (J)

k = the Boltzmann constant ($J K^{-1}$)

T = temperature (K)

(2)

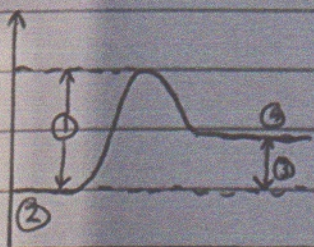
c) Activation energy is the energy required to get a reaction.
Exothermic



- 1 = activation energy
- 2 = energy of reactants
- 3 = energy released
- 4 = energy of products

(3)

Endothermic



- 1 = activation energy
- 2 = energy of reactants
- 3 = energy absorbed
- 4 = energy of products

Advanced Chemistry Exam

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Question 3

d) Nitrocellulose with an activation energy of 86 kJ mol^{-1} is less stable than RDX with an activation energy of 179 kJ mol^{-1} because it requires less energy in order to function. (2)

e) Stabilizers extend the life of NC based propellants by coating the NC making it less sensitive, for example add protection against activation by thermal energy, it also slows the rate of reaction. It protects against thermal runaway and weathering degradation. (1)

f) 30yr life @ 20°C . Rule of thumb, for every 10°C increase the rate of increase to 50°C reaction approximately doubles.

$$\therefore 30^\circ\text{C} = 15 \text{ yrs}$$

$$40^\circ\text{C} = 7.5 \text{ yrs}$$

$$50^\circ\text{C} = 3.75 \text{ yrs}$$

At 50°C the shelf life drops from 30yrs @ 20°C to roughly 3.75yrs @ 50°C . (3)

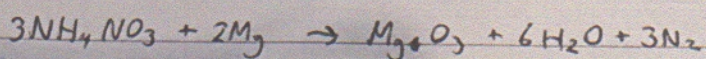
g) If the propelling charges are left in containers after time calculated then a possible hazard would be explosion via thermal runaway due to charge degradation. (1)

12
=

Question 4

- a) Hess's Law states that the overall enthalpy change that accompanies a reaction is independent of the route taken provided the initial and final states are the same.

- b) Ammonium Nitrate + Magnesium

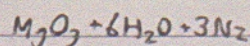
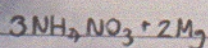


$$\text{Hf} = -958 \text{ kJ/mol} \quad -601 - (6 \times 242)$$

c) $\text{NH}_4\text{NO}_3 = -365 \text{ kJ/mol}^{-1}$

$\text{Mg}_2\text{O}_3 = -601 \text{ kJ/mol}^{-1}$

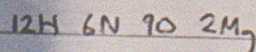
$\text{H}_2\text{O} = -242 \text{ kJ/mol}$



1095

-2053

$$\frac{-958}{288} = -3.32 \text{ kJ/g}$$



$$\text{H} = 1 \times 12 = 12$$

$$\text{N} = 14 \times 6 = 84$$

$$\text{O} = 16 \times 9 = 144$$

$$\text{Mg} = 24 \times 2 = 48$$

$$\text{MW} = 288$$

d) $\text{TNT } 1\text{g} = 2.8 \text{ kJ/g}$

Hf of ammonium nitrate + magnesium is -958 kJ/mol

MW of " is 288

$$\frac{-958}{288} = 3.32 \text{ kJ/g}$$

This reaction releases more energy than that of TNT.

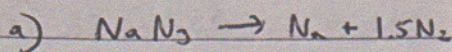
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Max Smith (1810364) 13/05/21

Question 5



(2)

b) 21g of nitrogen formed $N = 14$ $14 \times 1.5 = 21$

c) Sodium ~~oxide~~ stays solid. At STP 22.7 L of gas

$\therefore 1.5 \times 22.7 = 33\text{L}$ of gas formed.

(2)

d) Using Charles' Law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $V_1 = 33$ $V_2 = ?$
 $T_1 = 273.16$ $T_2 = 373.16$
 $\frac{33}{273.16} \times 373.16 = V_2$
 $= 45\text{L}$

(2)

e) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\therefore \frac{100 \times 10^3}{273.16} = \frac{P_2}{373.16}$
 $\left(\frac{100 \times 10^3}{273.16}\right) \times 373.16 = P_2 = 136.61 \text{ kPa}$

(2)

f) $PV = \frac{1}{2}mv^2$
 $\sqrt{\frac{PV}{0.5m}} = v$
 $\frac{(136.61 \times 10^3) \times 0.033}{0.5 \times 0.5} = 18032.52$

$\sqrt{18032.52} = v$

$134.29 = v$

(1)

Highest Theoretical Velocity = 134.29 ms^{-1}

g) In practice this cannot be achieved as it does not consider frictional loss on the barrel, heat loss on the barrel, gravitational loss, air resistance or noise and barrel length.

(11)

(2)

Advanced Chemistry Exam

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Question 6

- a) Nitrocellulose is part of the nitro groups. The correct name is cellulose nitrate. (2)
~~nitrate~~ and nitro are NO_2
nitrate is NO_3 $\swarrow$ so using nitro is misleading in the name.
- b) Purification and mechanical prep of raw cotton or cotton linters
Nitration of the cotton with nitric and sulphuric acid to produce nitrocellulose
Pulping
Washing
Peaching (3)
Wringing
Mixing
Granulating
Drying + Blanding
- c) Sulphuric acid creates the nitronium ion in the manufacture process. It is done through protonation of nitric acid by sulphuric acid which causes the loss of a water molecule and formation of nitronium ion. A nitronium ion can enable a faster reaction. (2)
- d) Peaching deliberately decomposes unstable impurities which might otherwise cause accelerated decomposition leading to ignition. (2)
- e) Low nitrogen nitrocellulose is less than 12% nitrogen.
High nitrogen nitrocellulose exceeds 12% nitrogen content. (1)

Question 6

f) Single base composed of 90+% nitrocellulose and a plasticiser.

Used in all kinds of guns from pistols to artillery.

Double base composed of nitrocellulose, nitroglycerine and a plasticiser.

Used in ~~higher calibre~~ guns, pistols and mortars.

Triple base composes of nitrocellulose, nitroglycerine, nitroguanidine and a plasticiser

Used in tank guns, larger calibre guns and UK Naval guns.

(6)

g) Double base propellants cause excessive erosion of the gun barrel due to higher temperature and the presence of muzzle flash which can be used to locate the gun.

h) Nitrocellulose is still in service because the components are naturally occurring and cheap. It is mixed with stabilisers which reduce likelihood of combustion. It is easy to transport and cheap. Manufacturing process is simple and cheap in comparison to others.

(17)

(18)

(1)

Question 7

a) Sensitivity is the degree to which an explosive can be initiated by impact, heat or friction.

Sensitiveness is the measure of how easy it is to detonate an explosive.

b) Emulsion explosives are typically used in mining and other industrial activities. They are relatively safe, can be manufactured on site, cheap easy to transport. (3)

c) Ammonium Nitrate is an oxidiser

Sodium Nitrate is an oxidiser, it also increases VoD and reduces critical diameter and increases sensitivity

Water is a suspension agent/stabiliser

Oil is a fuel

Aluminium is a fuel/sensitiser

Sorbitan Sesquiolate is an emulsifier

Glass microballoons are sensitisers.

(7)

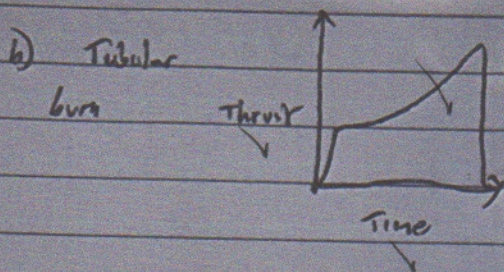
d) Microscopic droplets of ammonium nitrate solution surrounded by oil, thus waterproof. (2)

e) Microballoons create spaces in the solution which allow for hot spots, thus making more sensitive. (3)

(15)

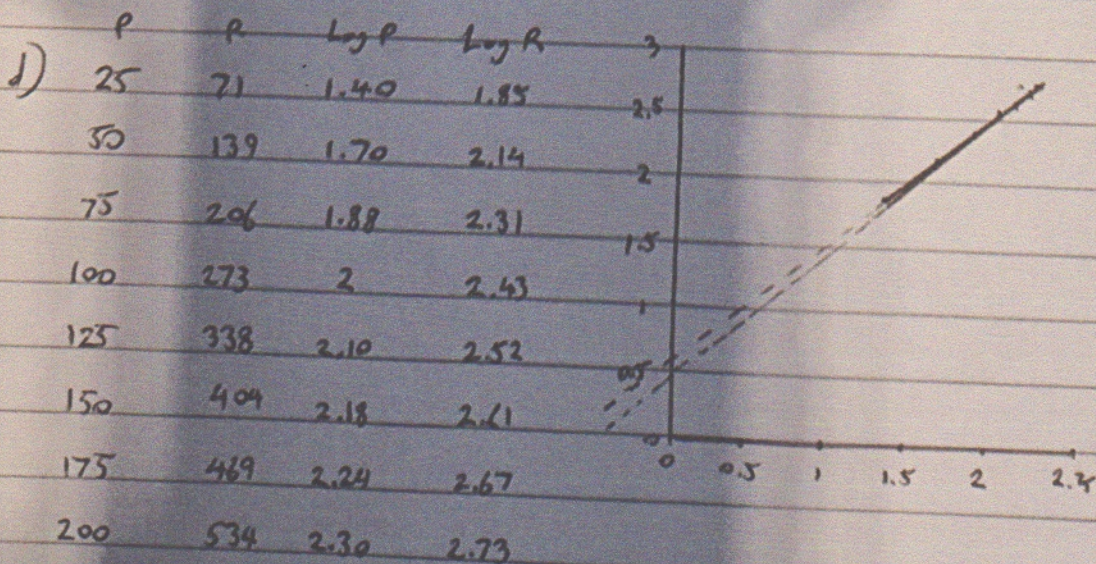
Question 8

- a) The pressure time profile can be controlled by:
- the chamber geometry
 - the chemistry of the propellant
 - the geometry of the propellant



- c) Vieille Law is $r = \beta P^\alpha$ where:
- r = burning rate (mm s^{-1})
 - β = burning rate coefficient (propellant specific)
 - P = pressure (MPa)
 - α = pressure index

If the value of the pressure index (α) is very close to 0, the burning rate becomes independent of pressure.



$\alpha = 0.97 \text{ MPa}$

$\beta = 0.47$