

"Dissemination of Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe
Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Autonomous)
Department of Physics

M.Sc. Part- I
Elements of Modern Physics
Surprise Test

Date : 21/10/2021
Day: - Saturday

Total Marks: 20
Time :- 2pm to 3pm

Instructions:-

- 1) All questions are compulsory.
- 2) Each question carries 5 marks.
- 3) Use of log table and calculator is allowed.

Q1) Select correct alternative.

(05)

1. When two or more number of electrons from one atom may transfer to another atom then bond is formed

- a) ionic b) covalent c) saturated d) nuclear

2. In the classical expression for energy of rotating diatomic molecule , there is no restriction on the value of

- a) L b) S c) Q d) N

3. In rotating spectra , the selection rule for transition is

- a) $\Delta J = 3$ b) $\Delta J = 2$ c) $\Delta J = 0$ d) $\Delta J = 1$

4. The spectral lines formed on low frequency side of exciting lines are known as

- a) Stocks lines b) Anti stocks lines c) Raman Lines d) IR lines

5. In experimental setup of Raman effect, cylinder is filled with saturated solution of

- a) Sodium Nitrate b) HCl c) Water d) Sodium Chloride

Q 2: Long answer question (any one)

(10)

1. Explain quantum theory of Raman effect
2. Explain diatomic molecule as a rigid rotator. Also find its energy states

Q 2: Long answer question (any one)

(05)

1. Explain various types of atomic bonds
2. Explain classical theory of Raman effect



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Department of Physics

B.Sc. III
Elements of Modern Physics
Surprise Test
Result

Date : 21/10/2021

Roll. No.	Marks	Roll. No.	Marks
8201	-	8225	07
8202	19	8226	-
8203	08	8227	-
8204	18		
8205	07		
8206	16		
8207	-		
8208	-		
8209	09		
8210	11		
8211	-		
8212	10		
8213	08		
8214	15		
8215	03		
8216	-		
8217	-		
8218	-		
8219	-		
8220	19		
8221	09		
8222	-		
8223	-		
8224	-		

Teacher Incharge.....

K Kamble
(Shri C.J. Kamble)

M
Head of the
Department of Physics
Vivekanand College, Kolhapur



॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

27443

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature
of
Supervisor

Suppliment No. :

Roll No. : 8202

Class : B.Sc. (III)

Subject : Elements of Modern Physics.

Test / Tutorial No. :

Div. :

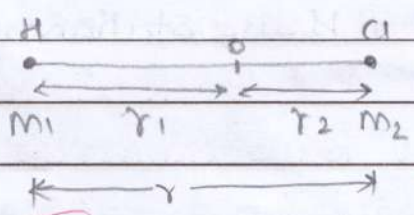
19/20

- 1)
- (1) (i) Ionic
- (2) (ii) L
- (3) (ii) $\Delta J = \pm 1$
- (4) (i) Stokes line
- (5) (i) Sodium Nitrate

04

- 2) The Quantization
- (2) The diatomic molecule as rigid rotator.

(i) The diatomic molecule consist of two atoms separated by intermolecular distance larger than the atomic demensions.
eg. HCl.



(ii) Consider a diatomic molecule, let O be the point on line joining centre of two atoms such that O is center of mass of the diatomic system.

$$\therefore m_1 r_1 = m_2 r_2$$

But here $r = r_1 + r_2$

$$\therefore r_2 = r - r_1$$

$$\therefore m_1 r_1 = m_2 (r - r_1)$$

$$m_1 r_1 = m_2 r - m_2 r_1$$

$$m_1 r_1 + m_2 r_1 = m_2 r$$

$$(m_1 + m_2) r_1 = m_2 r$$

$$\therefore r_1 = \frac{m_2 r}{m_1 + m_2}$$

Similarly, $r_2 = \frac{m_1 r}{m_1 + m_2}$

Now, The total moment of inertia of the system is

$$I = m_1 r_1^2 + m_2 r_2^2$$

$$= m_1 \left(\frac{m_2 r}{m_1 + m_2} \right)^2 + m_2 \left(\frac{m_1 r}{m_1 + m_2} \right)^2$$

$$= \left(\frac{m_1 m_2}{m_1 + m_2} \right) \times r^2$$

$$I = \mu r^2$$

Here μ is called as a reduced mass.

This reduced mass helps us to simplify the dynamics of diatomic system. Here we can consider that one of the atomic in the molecule is at rest while other is moving with respect to the first.

In case of HCl, we can say that H is stationary and the Cl atom is moving about it.

* Rotational energy states:-

Let ω be the angular velocity of the diatomic molecules.

Therefore we can give its rotational energy as follows.

$$E = \frac{1}{2} I \omega^2$$

$$E = \frac{I^2 \omega^2}{2I}$$

$$E = \frac{L^2}{2I} \quad \dots \text{(As Angular momentum, } L = I\omega \text{)}$$

According to classical theory, we can conclude that there is no restrictions on value of L and so, the energy is continuous i.e. 'E' can take all possible values.

• But As we know, According to Quantum Theory there are restrictions on the angular momentum, given by the eqⁿ

$$L = \sqrt{J(J+1)} \hbar \quad \dots \text{(Here } J \text{ is rotational Quantum no.)}$$

$$\therefore E = \frac{J(J+1) \hbar^2}{2I}$$

$$E = \frac{J(J+1) h^2}{8\pi^2 I}$$

$$E = B h^2 J(J+1)$$

(Here $B = \frac{h^2}{8\pi^2 I c}$ and c is velocity of light)

According to the above

eqⁿ,

If we consider the

values of $J = 0, 1, 2, 3, 4, \dots$

The corresponding values of rotational energies are

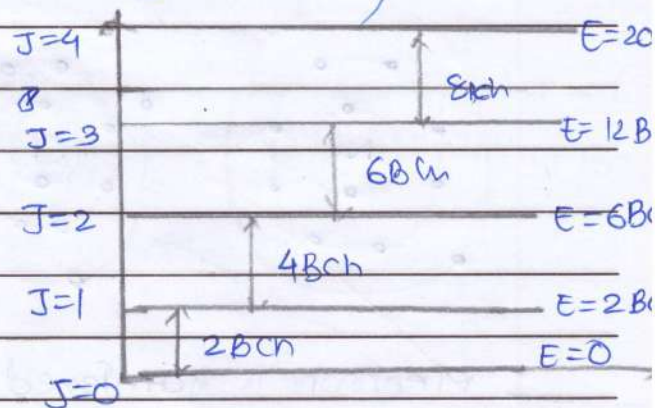
$$E_0 = 0,$$

$$E_1 = 2Bch$$

$$E_2 = 6Bch$$

$$E_3 = 12Bch$$

$$E_4 = 20Bch$$



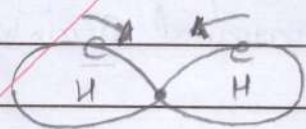
\therefore In rotational spectra,

the selection rule for transition is $\Delta J = \pm 1$

Q3) Types of bonds.

When two or more atoms with certain chemical properties come closer to each other they form a bond. This bond is the intermolecular attraction betw the atoms or constituents elements. The energy of a molecule is less than the energy of its constituents individually. Hence the molecules are much stable and ~~we~~ it needs energy to break the intermolecular bonds. When two or more atoms come closer the following three cases may occur,

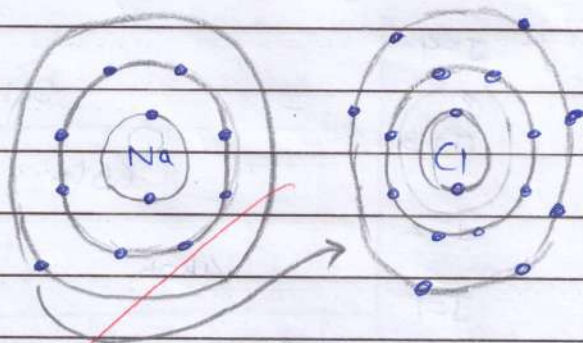
(1) Covalent Bonds :



When one or more pair of electrons are shared between two or more atoms then the bond formed is called an covalent bond.

The shared electrons spend more time between the nucleus of two atoms than elsewhere.

(2) Ionic Bonds :



When ~~two~~ ^{one} or more no. of e^- are transferred from one atom to another then the bond formed betw the atoms is Ionic Bond. Example : When ions of Na^+ & Cl^- come closer to each other ~~the~~ one electron is transferred and ionic bond is formed.

(3) No Bond formation :

When certain atoms come closer to each other, the atomic orbitals overlap. According to pauli's exclusion principle, no two e^- can have same quantum states. Therefore there is no bond formation between such atoms.

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SUPPLIMENT

Signature of Supervisor	
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Suppliment No. :

Roll No. : 8206

Class : BSc III

Subject : Physics, Elements of Modern Physics

Test / Tutorial No. : Internal exam

Div. :

16/20

Q1]

1) (ii) ionic

2) (iii) J

3) (iii) ± 1

4) (i) Stokes lines

5) (i) Sodium Nitrate

03



Aishwarya Deepak Shingade.

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- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

27455

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VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature
of
Supervisor

Suppliment No. : 01

Roll No. : 8214

Class : BSC-III.

Subject : Physics.

Test / Tutorial No. : Internal Exam

Div. : -

15/20

Q1.

- 1) When two or more number of electrons from one atom may transfer to another atom then ionic bond is formed.
- 2) In the classical expression for energy of rotating diatomic molecules, there is no restriction on the value of l.
- 3) In rotational spectra, the selection rule for transition is $\Delta J = \pm 1$.
- 4) The spectral lines found on low frequency side of exciting lines are known as Stokes lines.
- 5) In experimental set up of Raman Effect cylinder C is filled with saturated solution of Sodium Nitrate.

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Q2.

1) Quantum Theory of Raman Effect:

Raman effect is explained well with the help of quantum theory. It states that when any light is incident on a molecule in the form of photon, then after collision it is observed that the frequency of some photon is equal to the frequency of incident. But some frequencies of photons may be lower or higher than the incident radiations. The observations are as follows,

1) In elastic collision when a frequency of ν_0 is incident on a molecule in the form of photon. The frequency after collision is as equal to the incident frequency. If its frequency after collision is ν' then $\nu_0 = \nu'$.

This lines are known as Rayleigh line.

There is no change in frequency as no absorption is taken place.

2) In inelastic collision when a frequency of ν_0 is incident on a molecule in the form of photon, then is some absorption taken place. Thus the frequency obtained after collision is less than the incident frequency.

i.e. $\nu_0 > \nu'$. This lines are known as Stokes line. This are the lines found on the low frequency side of the exciting lines.

3) In inelastic collision when a frequency of ν_0 is incident on a molecule in the form of photon, then the some molecules are excited and they give there frequency to the incident frequency. Thus the frequency obtained after collision is greater than the incident frequency i.e. $\nu_0 < \nu'$. This lines are known as Antistokes line. This are the lines found on the high frequency side of the exciting lines.

The explanation of Antistokes is as follow,

⊙) Consider that,

E_p = Energy of photon before collision

E_q = Energy of photon after collision.

ν_0 = frequency incident frequency

ν' = Obtained frequency

By law of conservation of energy.

$$E_p = h\nu_0$$

$$E_q = h\nu'$$

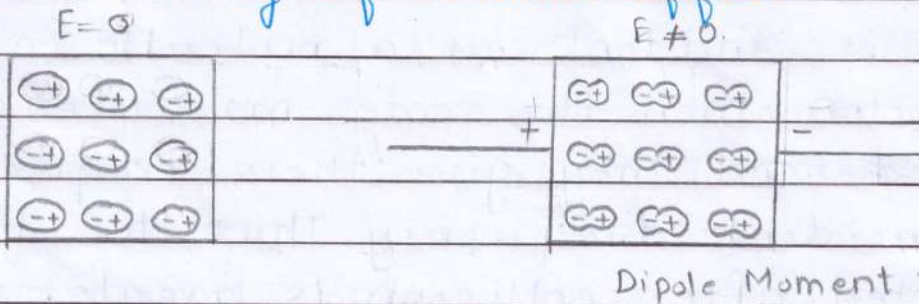
$$\therefore E_p - E_q = h(\nu_0 - \nu')$$

$$\therefore \frac{E_p - E_q}{h} = (\nu_0 - \nu')$$

$$\therefore \underline{\underline{\nu' = \frac{E_p - E_q}{h} + \nu_0}}$$

The above eqⁿ gives the frequency obtained after collision in Antistokes line.

Q3) Classical Theory of Raman Effect.



Classical theory states that when electrical field is applied to the a system, then the magnitude of electric field applied is directly proportional to the polarizability of the molecules.

$$\therefore P \propto E.$$

$$\therefore P = \alpha E. \quad \text{--- (1)}$$

Where α = Const of Polarizability

But Electric field is also given as,

$$E = E_0 \sin 2\nu_0 t. \quad \text{--- (2)}$$

\therefore from eqⁿ (1) & (2), we get

$$P = \alpha (E_0 \sin 2\nu_0 t).$$

But we also know that

$$\alpha = \alpha_0 + B \sin 2\nu_{vib} t. \quad \text{--- (3)}$$

Putting eqⁿ (3) in eqⁿ (2), we get

$$P = \alpha_0 + B \sin 2\nu_{vib} t (E_0 \sin 2\nu_0 t).$$

Where ν_{vib} = freq. when molecule vibrates

$$\therefore P = \alpha_0 E_0 \sin 2\nu_0 t + (B \sin 2\nu_{vib} t)(E_0 \sin 2\nu_0 t).$$

$$= \alpha_0 E_0 \sin 2\nu_0 t + E_0 B [\sin(2\nu_{vib} t) \sin(2\nu_0 t)].$$

$$= \alpha_0 E_0 \sin 2\nu_0 t + \frac{E_0 B}{2} [2 \sin(2\nu_{vib} t) \cdot \sin(2\nu_0 t)]$$

$$= \alpha_0 E_0 \sin 2\nu_0 t + \frac{E_0 B}{2} (\cos(\frac{2}{2}\nu_0 t - \frac{2}{2}\nu_{vib} t) - \cos(\frac{2}{2}\nu_0 t + \frac{2}{2}\nu_{vib} t)).$$