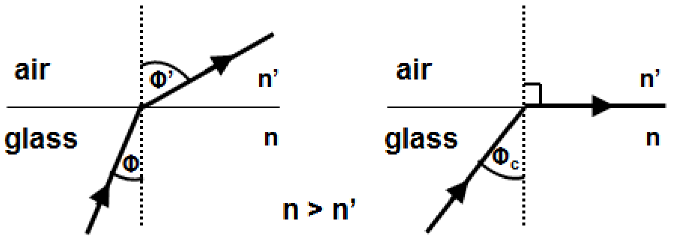
Benha University Faculty of Engineering – Shoubra Preparatory Year (New programs) Second Term (2018-2019)		Final Term Exam Physics 2 Date: 16 / 5 / 2019 Duration: 2 hours

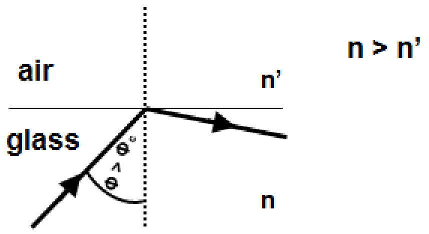
- Answer all the following question
- Illustrate your answers with sketches when necessary
- No. of questions: 4 questions
- Total Mark: 40 Marks

Question (1) **(12 marks)**

1-a) Give short notes on the phenomenon of total internal reflection and derive an expression for the critical angle of incidence?

When rays incident with a specific angle of incidence called "the critical angle" from a higher density medium to a lower density medium (n > n'), then the transmitted ray will be refracted at angle of refraction of 90°.





In this case, when the angle of incidence exceeds Φ_c , then the refracted rays make angle of refraction higher than 90°

So, the incident rays are considered to be reflected again in the medium of incidence

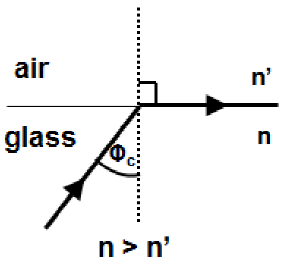
From Snell's law:

$n \sin \Phi = n' \sin \Phi'$

$n \sin \Phi_c = n' \sin 90°$

$\sin \Phi_c = n'/n$

$\Phi_c = \sin^{-1} (n'/n)$



The critical angle can be defined as: the angle of incidence in the higher density medium corresponding to an angle of refraction of 90° in the lower density medium.

1-b) An object is placed 50 cm in front of a concave mirror of focal length 30 cm. where will be its image formed? Find the magnification?

f = + 30 cm

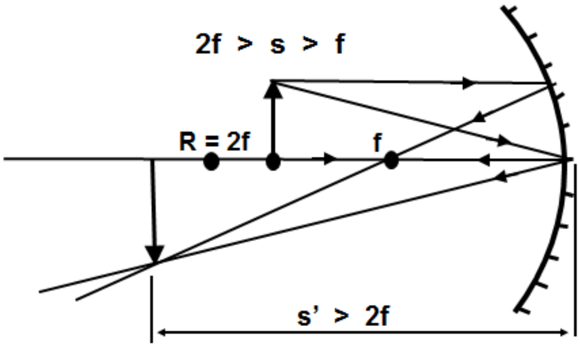
s = + 50 cm

1/s + 1/s' = 1/f

1/٥٠ + 1/s' = 1/٣٠

1/s' = 1/٧٥

s' = ٧٥ cm



M = – s' / s

M = – 75 / 50 = – 1.5

1-c) What type of lenses is required in order to obtain an inverted real image of three times the length of the object? Where the object must be placed in this case if the lens has focal length of 30 cm?

Convex lens

f = + 30 cm

M = – 3

M = – v/u

– v/u = – 3

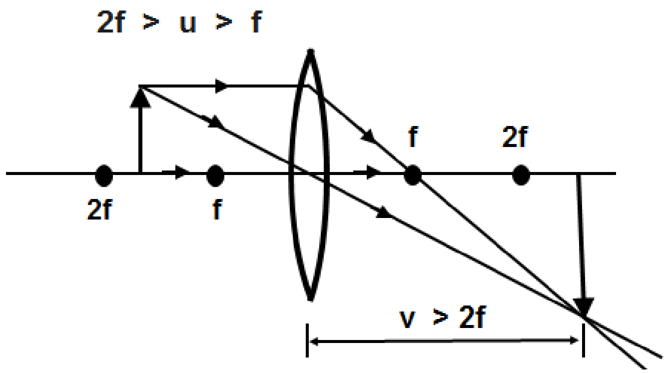
so, v = 3 u

1/u + 1/v = 1/f

1/u + 1/(3u) = 1/30

4/(3u) =1/30

u = 40 cm



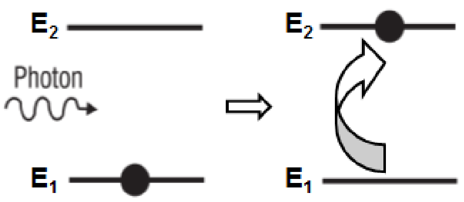
<u>**Question (2)**</u> <u>**(8 marks)**</u>

2-a) What does the word "LASER" mean? Explain with schematic diagrams the main characteristics of stimulated absorption, stimulated emission and spontaneous emission of light?

<u>LASER</u> word comes from:

<u>L</u>ight <u>A</u>mplification by <u>S</u>timulated <u>E</u>mission of <u>R</u>adiation

Stimulated absorption is the process in which an atom absorbs the energy of an incident photon. This causes an electron transition from a lower energy state to a higher energy state.



The rate of stimulated absorption can be given as:

With, $\frac{dN_1}{dt} \alpha N_1$ **and,** $\frac{dN_1}{dt} \alpha \rho$

So, $$\frac{dN_1}{dt} = B_{12} N_1 \rho$$

Where,

N_1 **: number of atoms in the lower energy state.**

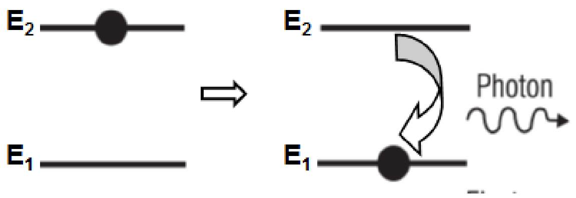
$\rho = \frac{I(v)}{4 \pi c}$ **is called the energy density of radiation,**

with $I(v)$ is the intensity of the incident radiation.

B_{12} **: Stimulated absorption rate coefficient, or,**

Einstein coefficient of stimulated absorption.

Spontaneous emission is the process in which an atom undergoes an electron transition from a higher energy state to a lower energy state spontaneously. This causes an emission of a light photon.



The rate of spontaneous emission can be given as:

With, $\frac{dN_2}{dt} \alpha N_2$

So, $$\left.\frac{dN_2}{dt}\right|_{sp} = A_{21} N_2$$

Where,

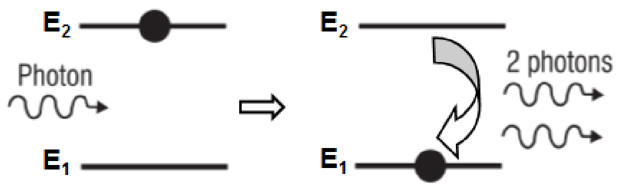
N_2 : number of atoms in the higher energy state.

$A_{21} = \frac{1}{\tau_{21}}$: Spontaneous emission rate coefficient, or,

Einstein coefficient of spontaneous emission.

With, τ_{21} is the transition life time from the higher to the lower level.

Stimulated emission is the process in which an atom interacts with the energy of an incident photon. This causes an electron transition from a higher energy state to a lower energy state. Two photons with the same frequency are produced in phase.



The rate of stimulated emission can be given as:

With, $\frac{dN_2}{dt} \alpha N_2$ and, $\frac{dN_2}{dt} \alpha \rho$

So, $$\left.\frac{dN_2}{dt}\right|_{st} = B_{21} N_2 \rho$$

Where,

N_2 : number of atoms in the higher energy state.

$\rho = \frac{I(v)}{4 \pi c}$ is called the energy density of radiation,

with $I(v)$ is the intensity of the incident radiation.

B_{21} : Stimulated emission rate coefficient, or,

Einstein coefficient of stimulated emission.

2-b) Calculate the spontaneous emission coefficient and the life time for an infrared transition whose frequency 4×10^{14} Hz if the corresponding stimulated emission coefficient is 10^{19} m^3/watt.s?
[c = 3 x 10^8 m/s, h = 6.6 x 10^{-34} J.s]

$$\frac{A_{21}}{B_{21}} = \frac{8\,\pi\, h\, \nu^3}{c^3}$$

$B_{21} = 10^{19}$ m^3/watt.s

$\nu = 4\times10^{14}$ Hz

$c = 3 \times 10^8$ m/s

$h = 6.6 \times 10^{-34}$ J.s

$A_{21} = 3.93 \times 10^5$ s^{-1}

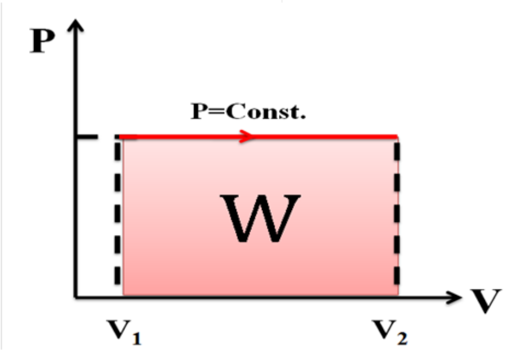
$\tau_{21} = 1/A_{21} = 2.5 \times 10^{-6}$ s

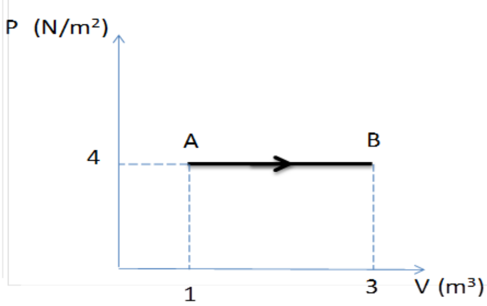
<u>Question (3)</u> **<u>(12 Marks)</u>**

3-a) Derive an expression for the work done by an ideal gas on the surrounding in isobaric process. Then for the P-V diagram calculate the work done for the process shown.

isobaric process: Is the process that occurs at **constant pressure**

$$P = constant \quad or \quad \Delta P = 0$$





$$W = \int_{V_1}^{V_2} P\,dV$$

W= area under the curve

$$W = P\int_{V_1}^{V_2} dV = P(V_2 - V_1)$$

W= p(V_2-V_1)= 4(3-1)= + 8 j

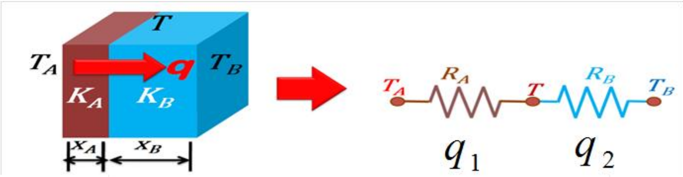
3-b) A 100 gm of ice at -15 °C is placed in a container. How much heat in joules must be added to raise the temperature of the ice to °C. (Given: c_{ice}=2060 J/kg °C)

$$Q = mC_{ice}\Delta t = 0.1 \times 2060 \times 15 = 3090\,J$$

3-c) A heat is conducted through a compound plate composed of two parallel plates of different materials A and B of conductivities 0.32 and 0.14 cal/cm.s.°C and each thickness 3.6 cm and 4.2 cm, respectively. If the temperature of the outer face of slab A and that of slab B are found to be steady at 96 °C and 8 °C respectively. Find the temperature of the interface A/B.

Solution

$K_A=0.32$ cgs, $K_B=0.14$ cgs, $X_A=3.6$ cm, $X_B=4.2$ cm, $T_A=96$ °C, $T_B=8$ °C, $T=??$,



$$q_1 = q_2$$

$$\frac{(T_1 - T)}{\frac{X_1}{K_1 A}} = \frac{(T - T_2)}{\frac{X_2}{K_2 A}}$$

$$\therefore \frac{(96 - T)}{\frac{3.6}{0.32}} = \frac{(T - 8)}{\frac{4.2}{0.14}} \Rightarrow \boxed{T = 72\ °C}$$

Question (4) (8 marks)

4-a) A proton moving at 4×10^{6} m/s through a magnetic field of 1.7 T experiences a magnetic force of magnitude 8.2×10^{-13} N. What is the angle between the proton's velocity and the field?

$F_B = qvB\sin\theta$ so $8.20\times10^{-13}\ \text{N} = (1.60\times10^{-19}\ \text{C})(4.00\times10^{6}\ \text{m/s})(1.70\ \text{T})\sin\theta$

$\sin\theta = 0.754$ and $\theta = \sin^{-1}(0.754) = \boxed{48.9° \text{ or } 131°}$.

4-b) A rectangular coil of dimensions 5.4 cm x 8.5 cm consists of 25 turns of wire and carries a current of 15 mA. A magnetic field of magnitude 0.35 T is applied parallel to the plane of the loop. Calculate the magnitude of the torque acting on it.

$$\mu_{coil} = NIA = (25)(15.0\times10^{-3}\ \text{A})(0.0540\ \text{m})(0.0850\ \text{m}) = 1.72\times10^{-3}\ \text{A}\cdot\text{m}^2$$

$$\tau = \mu_{coil}B = (1.72\times10^{-3}\ \text{A}\cdot\text{m}^2)(0.350\ \text{T}) = 6.02\times10^{-4}\ \text{N}\cdot\text{m}$$

GOOD LUCK,

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