



**FACULTY OF SCIENCE**

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**DEPARTMENT OF PHYSICS**

**MODULE: PHYL01A/PHYL1A1**

**PHYSICS FOR THE LIFE SCIENCES**

**CAMPUS: APK**

**JUNE SUPPLEMENTARY EXAM**

**EXAMINER:**

**MR K MURULANE**

**MODERATOR:**

**DR B SONDEZI**

**DURATION: 150 MINUTES**

**MARKS: 120**

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**NUMBER OF PAGES: 21 PAGES (including this information page)**

**INSTRUCTIONS:**

1. Answer ALL the questions in the question paper.
2. For question 1, circle the letters of the correct answers only.
3. Programmable calculators are not permitted.
4. Pencil may be used for diagrams only.
5. Work neatly

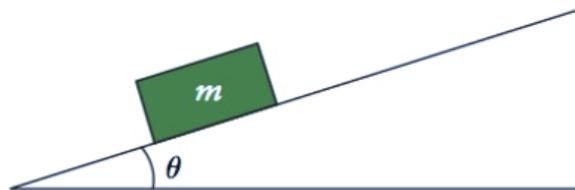
**QUESTION 1 [20]**

1.1 A particle is moving with a velocity  $v = k(yi + xj)$ , where  $k$  is a constant. The general equation for its path is

- (a)  $y = x^2 + \text{constant}$
- (b)  $y^2 = x^2 + \text{constant}$
- (c)  $xy = \text{constant}$
- (d)  $y^2 = x + \text{constant}$

[2]

1.2 A block of mass  $m$  rests on an inclined plane that makes an angle of  $\theta$  with the horizontal, as shown in the figure below. What is the static friction between the block and the inclined surface?



- (a)  $f_s \geq mg$
- (b)  $f_s \geq mg \cos \theta$
- (c)  $f_s = mg \sin \theta$
- (d)  $f_s = mg \cos \theta$
- (e) zero, because the plane is inclined

[2]

1.3 Two charges attract each other with a force  $F$ . If the magnitude of one of them is doubled, and the distance between them is doubled too, the magnitude of the force between them becomes

- (a)  $2F$ .
- (b)  $F$ .
- (c)  $F/2$ .
- (d)  $F/4$ .

1.4 A 70.0 kg person stands on a bathroom scale in an elevator. What does the scale read, in kg, if the elevator is slowing down at a rate of  $3.50 \text{ m/s}^2$  while descending?

- (a) 49.5 kg
- (b) 82.0 kg
- (c) 83.7 kg
- (d) 95.0 kg
- (e) 111.0 kg

[2]

1.5 When a torque acts on a rigid body, it always causes

- (a) constant angular velocity.
- (b) constant angular acceleration.
- (c) rotational equilibrium.
- (d) change in angular velocity.
- (e) change in moment of inertia.

[2]

1.6 A particle of mass  $m$  moves in a circle of radius  $r$  with a constant speed  $v$ . The magnitude of its angular momentum is

- (a)  $mr^2v$
- (b)  $(mr)^2v$
- (c)  $mv/r$
- (d)  $mrv$

[2]

1.7 We study the ideal gas law. The gas constant can be given in different units; however, which of the following units is wrong:

- (a) J/ (K mol).
- (b)  $(\text{atm } m^3)/ (\text{K mol})$ .
- (c)  $(\text{Pa } cm^2)/ (\text{K mol})$ .
- (d) cal/ (K mol).
- (e) None of the above; all are suitable for the gas.

[2]

1.8 If you perceive a point-like source of sound as too loud, you should move away from the source. This is because of the following relation between the sound intensity and the distance from the source.

- (a) Intensity is independent of distance.
- (b) Intensity increases linearly with distance.
- (c) Intensity decreases linearly with distance.
- (d) Intensity increases non-linearly with distance.
- (e) Intensity decreases non-linearly with distance.

[2]

1.9 When a torque acts on a rigid body, it always causes

- (f) constant angular velocity.
- (g) constant angular acceleration.
- (h) rotational equilibrium.
- (i) change in angular velocity.
- (j) change in moment of inertia.

[2]

1.10 When sound is absorbed in a medium, its intensity level IL decreases with distance travelled through the medium  $x$  as (Note:  $\beta$  is a constant)

- a)  $IL \propto e^{-\beta x}$ .
- b)  $IL \propto -x$ .
- c)  $IL \propto b$ .
- d)  $IL \propto \ln(-x)$ .

[2]

**QUESTION 2 [30]**

2.1 A Derive the kinematic equation  $\Delta x = v_0 t + \frac{1}{2} a t^2$  for constant acceleration. Explain all steps and symbols used. [6]

1. Consider a body moving with constant acceleration. Let  $v_0$  be the initial velocity &  $v$  be the final velocity. Let  $t$  be any arbitrary time. From the definition of acceleration,

$$a = \frac{v - v_0}{t} \rightarrow \textcircled{1}$$

Rearranging  $\textcircled{1} \rightarrow v = v_0 + at \rightarrow \textcircled{2}$

Since velocity is increasing or decreasing uniformly with time, the average velocity can be expressed as

$$\bar{v} = \frac{v + v_0}{2} \rightarrow \textcircled{3}$$

Let  $\Delta x$  be the displacement of the body. From definition of velocity we know we can write

$$\bar{v} = \frac{\Delta x}{t}$$

$$\therefore \Delta x = \bar{v} t = \left(\frac{v + v_0}{2}\right) t = \frac{1}{2}(v + v_0) t \rightarrow \textcircled{4}$$

(From  $\textcircled{3}$ )

Substituting  $\textcircled{2}$  in  $\textcircled{4}$  gives:

$$\Delta x = \frac{1}{2}(v_0 + at + v_0) t$$

$$\Delta x = v_0 t + \frac{1}{2} a t^2$$

(6 marks)

- 2.2 A sled rider rode a rocket-propelled sled that moved down a track at a speed of 10 km/h. He and the sled were safely brought to rest in 1.40 s. Determine the negative acceleration he experienced and the distance he travelled during this negative acceleration. [5]

$$a = \frac{v_f - v_i}{t}$$

$$v_f = 0$$

$$v_i = +10 \text{ km/h}$$

Now

$$v_f - v_i = 0 - 10 \text{ km/h} \checkmark$$

$$= -10 \text{ km/h} \times \frac{10^3 \text{ m} \cdot \text{h}}{3600 \text{ s} \cdot \text{km}} \quad (5)$$

$$= -2.78 \text{ m/s} \checkmark$$

$$\therefore a = \frac{-2.78 \text{ m/s}}{1.40 \text{ s}} \approx -1.99 \text{ m/s}^2 \checkmark \underline{\underline{2 \text{ m/s}^2}}$$

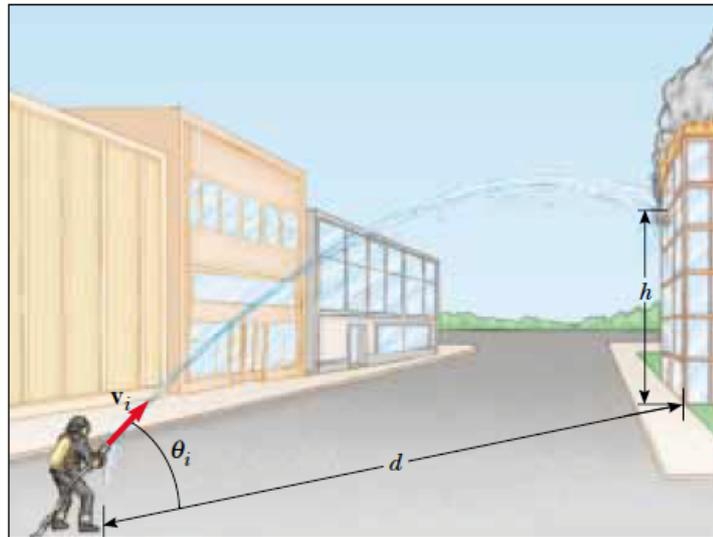
Now

$$x_f = v_i t + \frac{1}{2} a t^2$$

$$= 2.78(1.4) - \frac{1}{2} (2)(1.4)^2 \checkmark$$

$$\approx \underline{\underline{1.93 \text{ m}}} \checkmark$$

2.3 A firefighter, a distance  $d$  from a burning building, directs a stream of water from a fire an angle  $\theta$  above the horizontal as in figure below. If the initial speed of the stream is  $v_i$  at what height  $h$  does the water strike the building? [4]



⑤

$|\vec{v}_0| = 40 \text{ m/s}$   
 $+g = +9.8 \text{ m/s}^2$   
 $y_0 = 0$   
 $x_0 = 0$   
 $\Delta x = 50 \text{ m}$

$v_{0x} = 40 \text{ m/s} \cos 30^\circ = 34.6 \text{ m/s} \quad \checkmark$   
 $v_{0y} = 40 \text{ m/s} \sin 30^\circ = 20 \text{ m/s} \quad \checkmark$

$\Delta x = v_{0x} t \rightarrow t = \frac{\Delta x}{v_{0x}} = \frac{50 \text{ m}}{34.6 \text{ m/s}} = 1.44 \text{ s} \quad \checkmark$

$\Delta y = y - y_0 = v_{0y} t - \frac{1}{2} g t^2 = \left( \frac{20}{3} \right) (1.44 \text{ s}) - \frac{1}{2} (9.8 \frac{\text{m}}{\text{s}^2}) (1.44 \text{ s})^2$   
 $= 18.7 \text{ m}$

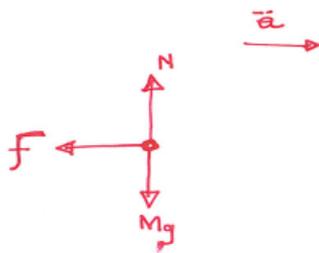
$y = 18.7 \text{ m}$

14 MARKS

- 2.4 You are in a taxi, sitting next to the driver. If he suddenly pushes the accelerator, you feel a push against your seat. If he suddenly pushes the brakes and comes to a stop, you feel a push forward toward the dashboard. Explain these situations according to the most suitable of Newton's laws. [3]

**As a passenger, your body moves with the same velocity as the car while it is being driven. When the driver pushes brakes, they apply a stopping force on the car but not on the passenger's body. So, according to Newton's first law, your body will continue moving forward with the same velocity**

- 2.5 A 1800 kg car is travelling at 24 m/s when its brakes fail. The driver manages to turn off the engine. How far will the car go before it comes to stop if the force of friction between the tire and the road is 4900 N. [6]



*f* is the only force acting horizontally on the moving car, but in the opposite direction of its motion.

2nd law implies,  $\sum \vec{F} = m\vec{a}$

Horizontally,  $\sum F_x = m\vec{a}$

$$-4900 \text{ N} = (1800 \text{ kg}) \vec{a}$$

$$\vec{a} = \frac{-4900 \text{ N}}{1800 \text{ kg}} = -2.72 \text{ m/s}^2$$

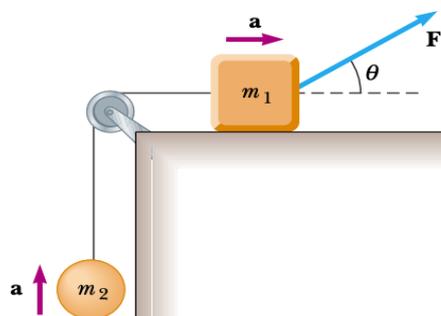
Now using Kinematics;

$$v^2 - v_0^2 = 2ax$$

$$0 - (24 \text{ m/s})^2 = 2(-2.7 \text{ m/s}^2) \cdot x$$

$$x = \frac{(24 \text{ m/s})^2}{2(+2.7 \text{ m/s}^2)} = 105.88 \text{ m} \approx \underline{\underline{106 \text{ m}}}$$

2.6 block of mass  $m_1$  on a rough, horizontal surface is connected to a ball of mass  $m_2$  by a lightweight cord over a lightweight, frictionless pulley, as shown in the Figure below. A force of magnitude  $F$  at an angle with the horizontal is applied to the block as shown. The coefficient of kinetic friction between the block and surface is  $\mu_k$ . Determine the magnitude of the acceleration of the two objects. [6]



Free body diagrams and equations:

For mass  $m_2$  (ball):

$\sum F_x = \sum F_{x,ball} = m_2 a_x = 0$  — (1)

$\sum F_y = \sum F_{y,ball} = T - m_2 g = m_2 a_y = m_2 a$  — (2)

For mass  $m_1$  (block):

$\sum F_x = \sum F_{x,block} = F \cos \theta - f_k - T = m_1 a_x = m_1 a$  — (3)

$\sum F_y = N + F \sin \theta - m_1 g = m_1 a_y = 0$  — (4)

We know that  $f_k = \mu_k N$  — (5)

From (4)  $N = m_1 g - F \sin \theta$

$\therefore f_k = \mu_k (m_1 g - F \sin \theta)$  ✓

From (2)  $T = m_2 g + m_2 a$

Now sub  $f_k$  and  $T$  in (3).

$F \cos \theta - \mu_k (m_1 g - F \sin \theta) - (m_2 g + m_2 a) = m_1 a$

$F \cos \theta + \mu_k F \sin \theta - \mu_k m_1 g - m_2 g = m_1 a + m_2 a$

$\Rightarrow a = \frac{F(\cos \theta + \mu_k \sin \theta) - g(m_2 + \mu_k m_1)}{(m_1 + m_2)}$  ✓

(5 marks)

**QUESTION 3 [30]**

- 3.1 The mass of the Earth is  $5.98 \times 10^{24}$  kg, and the mass of the Moon is  $7.36 \times 10^{22}$  kg. The distance of separation, measured between their centres, is  $3.84 \times 10^8$  m. Locate the centre of mass of the Earth–Moon system as measured from the centre of the Earth. [4]

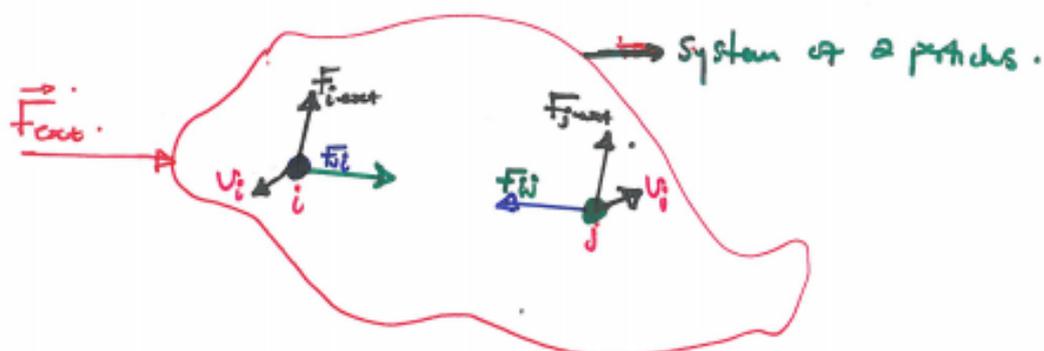
Let the  $x$ -axis start at Earth's centre and point towards the moon;

$$\therefore x_{cm} = \frac{1}{m_1 + m_2} \sum_{i=1}^n m_i x_i$$

$$= \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{(5.98 \times 10^{24}) \cdot 0 + (7.36 \times 10^{22})(3.84 \times 10^8)}{5.98 \times 10^{24} + 7.36 \times 10^{22}}$$

$$= 4.67 \times 10^6 \text{ m from Earth's centre.}$$

3.2 Show that the total linear momentum of an isolated system does not change in time. [7]



The net force of the system is given by

$$F_{\text{net}} = \sum F = \sum F_i + \sum F_j \quad \checkmark$$

$$= (F_{i\text{ext}} + F_{ji}) + (F_{j\text{ext}} + F_{ij})$$

From (3rd law) we know that:

$$F_{ij} = -F_{ji} \quad \checkmark$$

Now,

$$F_{\text{net}} = F_{i\text{ext}} + F_{ji} + F_{j\text{ext}} - F_{ji} \quad \checkmark$$

$$F_{\text{net}} = F_{i\text{ext}} + F_{j\text{ext}} = F_{\text{ext}} \quad \checkmark$$

$\therefore$  We know that  $F_{\text{net}} = M a_{\text{cm}}$   $\checkmark$

$$\therefore F_{\text{ext}} = F_{i\text{ext}} + F_{j\text{ext}} = M a_{\text{cm}} \quad \checkmark$$

$$= m_i a_i + m_j a_j = M a_{\text{cm}} \quad \checkmark$$

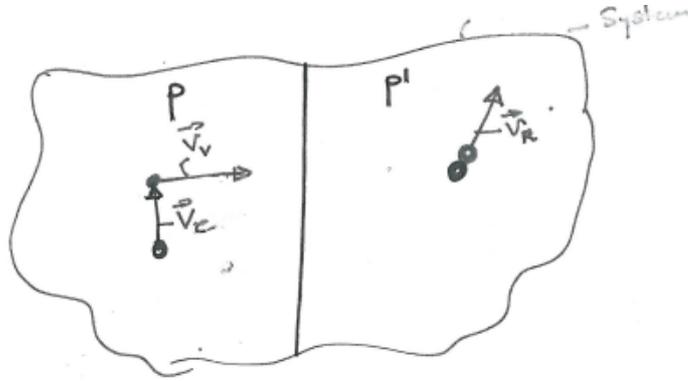
$$F_{\text{ext}} = m_i \frac{dv_i}{dt} + m_j \frac{dv_j}{dt} = M \frac{dv_{\text{cm}}}{dt} \quad \checkmark$$

$$F_{\text{ext}} = \frac{dP_i}{dt} + \frac{dP_j}{dt} = \frac{dP_{\text{tot}}}{dt} \quad \checkmark$$

$$\therefore \frac{dP_{\text{tot}}}{dt} = F_{\text{ext}} \quad , \text{ for } F_{\text{ext}} = 0 \quad \frac{dP_{\text{tot}}}{dt} = 0 \quad \checkmark$$

$$\Rightarrow P = C \Rightarrow P = P' \quad \text{[Total linear momentum is conserved]} \quad \checkmark$$

3.3 A car with a mass of 1200 kg and a speed of 12 m/s heading north approaches an intersection. At the same time, a minivan with a mass of 1300 kg and speed of 24 m/s heading east is also approaching the intersection. The car and the minivan collide and stick together. What is the velocity of the wrecked vehicles just after the collision? Ignore friction between the tires and the surface of the road. [7]



⇒ System is isolated, thus no friction.

∴  $F_{net} = \frac{dP}{dt} = 0$ ,  $P \Rightarrow$  the total momentum is conserved.

Now  $P = P'$ ,  $P$  - total momentum before,  $P'$  - ... .. after.

∴  $P_c + P_v = P'_R$ ,  $R = V + C$

note that  $P_c \perp P_v$  thus

∴  $P_R^2 = P_c^2 + P_v^2 \Rightarrow P_R = \sqrt{(P_c)^2 + (P_v)^2}$   
 $= \sqrt{(m_c v_c)^2 + (m_v v_v)^2}$   
 $= \sqrt{((1200)(12))^2 + ((1300)(24))^2}$

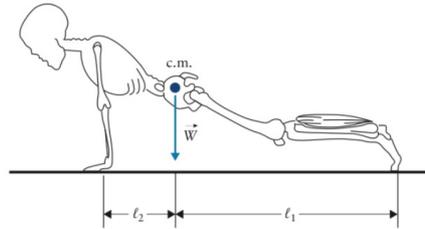
$P_R = 34362.7 \text{ kgm/s}$

Now  $P_R = m_R V_R$   
 $V_R = \frac{P_R}{m_R} = \frac{34362.7}{2500} = 13.7 \text{ m/s}$

3.4 Explain why you cannot open a door by pushing on its hinge side [2]

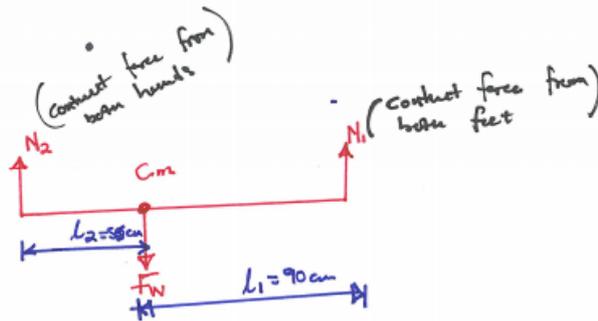
**The distance will be  $r = 0$  and, therefore, the torque will be  $\tau = 0$ , so that no change in rotational motion is possible; you cannot open the door.**

3.5 A standard man is doing push-ups, as shown in the figure below. The distances are  $l_1 = 90 \text{ cm}$  and  $l_2 = 55 \text{ cm}$ . Calculate the vertical component of the normal force exerted by the floor on both hands, and the normal force exerted by the floor on both feet. [6]



Here the entire standard man is the system.  
i.e. The extended rigid object = standard man.

also Com is the center of mass of the system and it is also the axis of rotation.



System is in equilibrium.

$$\text{i.e. } \sum F = F_{\text{net}} = 0 \quad \text{--- (1)}$$

$$\sum \tau = \tau_{\text{net}} = 0 \quad \text{--- (2)}$$

$$\text{From (1)} \quad N_2 + N_1 - FW = 0 \quad \text{--- (3)}$$

$$\text{From (2)} \quad N_2 l_1 - N_1 l_2 = 0 \quad \text{--- (4)}$$

$\left\{ \begin{array}{l} \tau = r \perp F \\ \text{here } \phi = 90 \text{ for both } N_1 \text{ and } N_2 \end{array} \right.$

$$\text{From (3)} \quad N_1 = FW - N_2 \quad \text{--- (5)}$$

sub (5) in (4)

$$(FW - N_2) l_1 - N_2 l_2 = 0$$

$$FW l_1 - N_2 l_1 - N_2 l_2 = 0 \quad \text{--- (6)}$$

$$\Rightarrow FW \cdot l_1 = N_2 (l_1 + l_2) \Rightarrow N_2 = \frac{F_{\text{WS}} \cdot l_1}{(l_1 + l_2)} = \frac{(70)(95)(0.9)}{(0.55 + 0.9)} = 426 \text{ N}$$

$$\text{From (4)} \quad N_2 l_2 = N_1 l_1$$

$$N_1 = \frac{N_2 l_2}{l_1} = \frac{426(0.55)}{0.9} = 260 \text{ N}$$

- 3.6 A 1.50-kg particle moves in the  $xy$  plane with a velocity of  $\vec{v} = (4.2 \hat{i} - 3.6 \hat{j}) \text{ m/s}$ . Determine the angular momentum of the particle when its position vector is  $\vec{r} = (1.5 \hat{i} + 2.2 \hat{j}) \text{ m}$ . [4]

$$\mathbf{L} = \mathbf{r} \times \mathbf{p}$$

$$\mathbf{L} = (1.50\hat{i} + 2.20\hat{j}) \text{ m} \times (1.50 \text{ kg})(4.20\hat{i} - 3.60\hat{j}) \text{ m/s}$$

$$\mathbf{L} = (-8.10\hat{k} - 13.9\hat{k}) \text{ kg}\cdot\text{m}^2/\text{s} = \boxed{(-22.0 \text{ kg}\cdot\text{m}^2/\text{s})\hat{k}}$$

**QUESTION 4 [25]**

- 4.1 If a person lifts an 18.0 kg bucket from a well and does 5.50 kJ of work, how deep is the well? Assume that the weight is lifted at a constant speed. **[5]**

The work done by the person is of the same magnitude but opposite sign of the work done by gravity. This is emphasized in the problem by stating that the bucket is lifted at constant speed. Since the gravitational force is collinear with the displacement but opposite in direction, the work done  $W_g$  is:

$$W_g = -mgd, \quad (1)$$

where  $m = 18.0$  kg,  $g = 9.80$  m/s<sup>2</sup>, and  $d$  is the depth of the well (equal to the height to which that the bucket is raised). Since the work done by the person is  $W = -W_g = 5.50$  kJ, we find from Eq. [1]:

$$W = -W_g = mgd \quad (2)$$

Solving for  $d$  in Eq. [2]:

$$\begin{aligned} d &= \frac{W}{mg} \\ &= 31.2\text{m}. \end{aligned}$$

So, the well is 31.2 m deep.

- 4.2 A medical student volunteers to have his lung volumes measured for his organ physiology laboratory class. He is connected to a 3.0 L spirometer containing a concentration of helium which is 5% the volume of spirometer. He is instructed to breath several times until the helium has equilibrated between the spirometer and his lungs. He is then instructed to exhale as much air as he possibly can. Calculate the lung volume after the student has exhaled the maximum air out of his lungs provided only 3% of the helium concentration is left in the spirometer. [6]

$$V_{\text{He}_1} = f_i \cdot V_s$$

$$f_i = 5\%$$

$$V_s = 3.0 \text{ L}$$

$$V_{\text{He}_1} = 5\% (3.0 \text{ L}) =$$

$$V_{\text{He}_2} = f_f (V_s + V_L)$$

$$f_f = 3\%$$

$$\therefore V_{\text{He}_2} = 3\% (3.0 + V_L)$$

$$3\% (V_L) = -3\% (3.0) + 5\% (3.0)$$

$$V_L = -3.0 + \frac{5\%}{3\%} (3.0)$$

$$V_L = 3.0 \left( \frac{5\%}{3\%} - 1 \right) = \underline{\underline{2 \text{ L}}}$$

- 4.3 Water boils at  $p = 1 \text{ atm}$  and  $100^\circ\text{C}$ . Its density in the liquid state at the boiling point is  $0.96 \text{ g/cm}^3$ . Calculate the volume ratio of water vapour to liquid water at the boiling point. **Hint:** Model water vapour as an ideal gas. You may use a reference amount of water of 1 mol if this simplifies your calculations. [6]

Using the ideal gas law, the volume of water vapour is:

$$V_{\text{vapour}} = \frac{nRT}{p}. \quad (1)$$

Using the density  $\rho$ , the total mass  $m_{\text{total}}$ , and the molar mass  $M$ , we can write the volume of liquid water as:

$$V_{\text{liquid}} = \frac{m_{\text{total}}}{\rho} = \frac{nM}{\rho}. \quad (2)$$

The required quantity is the ratio of Eq. [1] to Eq. (2):

$$\frac{V_{\text{vapour}}}{V_{\text{liquid}}} = \frac{nRT/p}{nM/\rho} = \frac{\rho RT}{pM}. \quad (3)$$

Substituting the given values and the molar mass of water as  $18.0 \text{ g/mol}$  into Eq. [3], we obtain:

$$\begin{aligned} \frac{V_{\text{vapour}}}{V_{\text{liquid}}} &= \frac{(8.314 \text{ J/K}\cdot\text{mol})(373\text{K})(960 \text{ kg/m}^3)}{(0.018 \text{ kg/mol})(1.013 \times 10^5 \text{ Pa})} \\ &= 1630 \end{aligned}$$

- 4.4 State the first law of thermodynamic for a closed system and express it mathematically. [3]

**The sum of all energy forms in a closed system changes by the amounts of heat and work that flow between the system and the environment.**

$$\Delta U_{\text{closed system}} = Q + W$$

- 4.5 A 1.0-mol sample of an ideal gas is kept at 0.0°C during an isothermal expansion from 3.0 L to 10.0 L. (a) Calculate the work done on the gas during the expansion and (b) the energy transferred by heat that occurs with the surroundings in this process . [5]

$$\begin{aligned} W &= nRT \ln \left( \frac{V_i}{V_f} \right) \\ &= (1.0 \text{ mol}) (8.31 \text{ J/mol} \cdot \text{K}) (273 \text{ K}) \ln \left( \frac{3.0 \text{ L}}{10.0 \text{ L}} \right) \\ &= -2.7 \times 10^3 \text{ J} \end{aligned}$$

**Solution** From the first law, we find that

$$\begin{aligned} \Delta E_{\text{int}} &= Q + W \\ 0 &= Q + W \\ Q &= -W = 2.7 \times 10^3 \text{ J} \end{aligned}$$

**QUESTION 5 [15]**

5.1 The intensity of spherical wave 10 m from the source is  $100 \text{ W/m}^2$  What is the intensity at a point 20 m away from the source? [5]

$$\frac{I_2}{I_1} = \frac{P/r_2^2}{P/r_1^2} = \frac{P/r_2^2}{P/r_1^2} \quad \checkmark$$

$$\frac{I_2}{I_1} = \frac{r_1^2}{r_2^2} = \frac{1}{4} \quad \checkmark$$

$$\begin{aligned} \therefore I_2 &= I_1 \cdot \frac{1}{4} \\ &= 100 \text{ W/m}^2 \cdot \frac{1}{4} \quad \checkmark \\ &= 25 \text{ W/m}^2 \quad \checkmark \end{aligned}$$

5.2 Given that the relation between the maximum transmitted and incident speeds is given by  $v_t = \frac{2\rho_1 c_1}{2\rho_1 c_1 + 2\rho_2 c_2} v_i$ . Derive the ratio of reflected to incident intensity  $R_I$ .

[6]

Intensity Reflection.

$$R_I = \frac{I_r}{I_i} = \frac{\frac{1}{2} \rho_1 c_1 v_r^2}{\frac{1}{2} \rho_1 c_1 v_i^2}$$

$$\Rightarrow \frac{v_r^2}{v_i^2}$$

but  $v_r = v_t - v_i$

$$= \frac{2Z_1}{Z_1 + Z_2} v_i - v_i$$

$$v_r = v_i \left( \frac{2Z_1}{Z_1 + Z_2} - 1 \right)$$

$$= v_i \left( \frac{2Z_1 - (Z_1 + Z_2)}{Z_1 + Z_2} \right)$$

$$= v_i \left( \frac{Z_1 - Z_2}{Z_1 + Z_2} \right)$$

Now

$$R_I = \frac{v_i^2 \left( \frac{Z_1 - Z_2}{Z_1 + Z_2} \right)^2}{v_i^2}$$

$$= \left( \frac{Z_1 - Z_2}{Z_1 + Z_2} \right)^2$$

5.3 Explain why an observer moving toward or away from a stationary source of sound perceives an apparent frequency that is not the true frequency of the source. [4]

When an observer moves toward a stationary source of sound, the wavelength of the sound itself does not change; it is a property of the source. However, the observer hears an apparent frequency because he perceives the crests more frequently than he would if he was stationary (if he were moving away from the source he would perceive crests less frequently, and the frequency would seem to be lower than the frequency of the source). This is doppler effect. ✓

(3)

----End of paper----