H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET C

PAPER 2

ANSWER

Compiled by

THE PHYSICS CAFE

1. (a)(i) SI base units are **the units** for a set of physical quantities of measure or dimensions that are used to define all other SI units known as SI derived units.

(a)(ii)

	Magnitude	Unit
Resistance of a domestic filament lamp	10^3	Ω
Mass of Earth	(5.9742×) 10^{24}	kg
Size of nucleus	10^{-14} or 10^{-15}	m

(b)(i) Systematic error is present when the readings are scattered about a value other than the true value with a fixed pattern. Systematic errors have the same magnitude and sign.

Or

Consistent over-estimation or consistent underestimation.

(b)(ii)

$$\frac{\Delta Q}{Q} x100\%$$

$$= 3(\pm\frac{0.03}{1.67})x100\%$$

$$= \pm 5.4\%$$

2 (a) tyre pushes backwards on the road.
Newton's third law therefore gives an equal and opposite force on a different body

This is the force the road exerts on the tyre
Motion here could be no relative motion between tyre and road
Larger forward force than drag therefore acceleration takes place

(b) the equal forces act on different objects
Example and/or clarification e.g. when an apple is falling the force the Earth exerts on the apple equals the force the apple exerts on the Earth
This force causes an appreciable acceleration of the apple but negligible acceleration of the Earth.

(c) the astronaut is accelerating / has centripetal acceleration
And the space station has the same acceleration
A person does not **feel** gravity
Only feels forces by contact with the walls of the space station but not from the floor on his feet.
No support force from the space station (as they have the same acceleration)

3 (a)(i) PV=nRT
$1.5x10^5$ x 2 = n (8.31) (300)
n = 120.3 = 120 moles (to 2 sf)

(a)(ii)

$$U = \frac{3}{2}nRT = \frac{3}{2}PV = \frac{1}{2}mv^2$$

$$\frac{3}{2}(1.5x10^5 x2) = (\frac{1}{2})(120.3 * 2.8x10^{-2})v^2$$

$$v = 518ms^{-1}$$

(b)(i) Case I:

New volume = 1.01 x 2.0 = 2.02 m^3

Work done by the gas in expanding $= \int_{2.0}^{2.02} p\,dv$

$= 1.5 \times 10^5 (2.02 - 2.0)$

= 3.0 kJ

(b)(ii) Case II:

Since heat supplied to the system is zero.
Using $\Delta U = Q + W$, the work done by the gas comes from the internal energy of the gas.
Since work is done by gas, W_{on} is negative, thus ΔU is negative.

Since $\Delta U = \frac{3}{2} nR\Delta T$, when there is a decrease in internal energy of the gas, there will be a decrease in temperature of the gas.

(c) (i) Sealevel, V = 10 m^3 P = 100 kPa
At 5000 m, V_1 = ? P_1 = 54 kPa
Using $(P_1V_1)/T_1 = (PV)/T$
$V_1 = 16.4\ m^3$

(c)(ii) Using PV = nRT,
n = (54000x16.4)/(8.31x255)= 417.9 mol
Mass = 0.029 x 417.9 = 12.1 kg
Density = mass / volume = 12.1 / 16.4 = 0.74 kg m^{-3}

4 (a) (i) The principle of conservation of linear momentum states that the initial momentum of a system before a collision is equal to final momentum of the system provided the net external force acting on the system is zero.

(ii) Principle of conservation of kinetic energy states that in the absence of any net external force or any internal non-conservative force, the total mechanical (or kinetic) energy of the system is conserved.

(b) (i) Principle of conservation of linear momentum and the Principle of Conservation of Kinetic Energy are observed.

(ii) Principle of conservation of linear momentum is observed but the Principle of Conservation of Kinetic energy is not observed.

(c)(i) $m_1u_1+m_2v_1 = m_1u_2 + m_2v_2$

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2v_1^2 = \frac{1}{2}m_1u_2^2 + \frac{1}{2}m_2v_2^2$

(c)(ii) $m_1(u_1 - u_2) = m_2(v_2 - v_1)$

$\frac{1}{2}m_1(u_1^2 - u_2^2) = \frac{1}{2}m_2(v_2^2 - v_1^2)$

(c)(iii) $m_1(u_1 - u_2) = m_2(v_2 - v_1)$

$\frac{1}{2}m_1(u_1 - u_2)(u_1 + u_2) = \frac{1}{2}m_2(v_2 - v_1)(v_2 + v_1)$

$\frac{1}{2}m_2(v_2 - v_1)(u_1 + u_2) = \frac{1}{2}m_2(v_2 - v_1)(v_2 + v_1)$

$(u_1 + u_2) = (v_1 + v_2)$ (shown)

5 (a) $f_d = 0.9/0.3 = 3$ Hz where f_d = driving frequency
When $f_n = f_d$, m = 0.0788kg where f_n = natural frequency

(b) (i) larger water amplitude means more energy transferred per unit time, so amplitude of block increases

(ii) increase distance means increase wavelength means decrease frequency. No resonance so amplitude of block decreases

6 a) **Spontaneous emission** refers to photons emitted naturally and randomly from excited states, while stimulated emission refers to photons causing other photons of the same frequency to be emitted from excited states.

b) Light and electricity are commonly used to selectively transfer energy to atoms or molecules, exciting them to higher energy levels, most of the time, a metastable state. The photon that any atom releases has a certain wavelength that is dependent on the energy difference between the excited state and the ground state. If this photon (possessing a certain energy and phase) should encounter another atom that has an electron in the same excited state, stimulated emission can occur. The first photon can stimulate or induce atomic emission such that the subsequent emitted photon (from the second atom) vibrates with the same frequency and direction as the incoming photon.
When a stimulated emission happens, one photon results in two in-phase photons. The initial two in-phase photons will create two simulated emissions, resulting in four in-phase photons and so on. A cascade effect occurs [1], and soon we have propagated many, many photons of the same frequency (energy) and in exactly the same direction in phase with the incident photon (conservation of momentum). [1] Thus, resulting in an intense (high intensity) and monochromatic (same frequency photons) light beam.

c) Power = intensity x area = $4.0 \times 10^{20} \times 7.2 \times 10^{-10} = 2.9 \times 10^{11}$ W

7(a) $\lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{1.24 \times 10^6}$

$= 5.59 \times 10^{-7}\ s^{-1}$

(b)(i) activity $= \frac{dN}{dt} = \lambda N$

$= \lambda \left(\frac{M}{M_m}\right) N_A$

Since $\frac{A}{M} \propto \frac{\lambda}{M_m}$

Thus, sodium, Na has the greatest activity per unit mass.

(b)(ii) activity $= \frac{dN}{dt} = \lambda N$

$= \lambda \left(\frac{M}{M_m}\right) N_A$

$= (1.28 \times 10^{-5})\left(\frac{1.0 \times 10^{-12}}{0.024} \times 6.02 \times 10^{23}\right)$

$= 3.2 \times 10^8\ s^{-1}$

(c) Phosphorus is the only one that is worthwhile as its activity drops to about $(0.5)^{7.8/1.24}$ i.e. 0.013 of its original activity in 3 months.

Am and Co not suitable as reduction in their activities are not significant.

For Na, it needs not be kept for such a long time of 3 months as a few days would be sufficient for its activity to reach a very low value for safe disposal.

(d) For every disintegration of ^{60}Co, a β particle of energy 0.496 x 10^{-13} J, a γ ray of energy 1.87 x 10^{-13} J and another γ ray of energy 2.13 x 10^{-13} J will be emitted.

For 100 disintegrations of ^{241}Am, 85 α particles of energy 8.78 x 10^{-13} J, and 13 α particles of energy 8.70 x 10^{-13} J are emitted. Another 2 disintegrations are not accounted for.

(e) The energy released per second by 2.68 x 10^{-9} cm^3 of Co is
= (3.00 x 10^6)(0.496 + 1.87 + 2.13)(10^{-13})
=1.3488 x 10^{-6} W

1 kW needs $\frac{1000}{1.3488 \times 10^{-6}} \times (2.68 \times 10^{-9})$
= 1.99 cm^3