**Leaving Cert Physics Worked Solutions 2003**

**LEAVING CERTIFICATE EXAMINATION 2003: PHYSICS – HIGHER LEVEL**

**2003 Question 1**

In an experiment to verify Boyle’s law, a student measured the volume *V* of a gas at different values of the pressure *p*.

The mass of the gas was not allowed to change and its temperature was kept constant.

The table shows the data recorded by the student.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *p/* kPa | 120 | 180 | 220 | 280 | 320 | 380 | 440 |
| *V*/cm3 | 9.0 | 6.0 | 5.0 | 4.0 | 3.5 | 3.0 | 2.5 |

1. **Describe with the aid of a diagram how the student obtained this data.**

See diagram.

Note the pressure of the gas from the pressure-gauge and the volume from the graduated scale.

Turn the screw to decrease the volume and increase the pressure.

Note the new readings and repeat to get about seven readings.

1. **Draw a suitable graph on graph paper to show the relationship between the pressure of the gas and its volume.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *p/* kPa | 120 | 180 | 220 | 280 | 320 | 380 | 440 |
| *1/V*/cm-3 | 0.111 | 0.167 | 0.200 | 0.250 | 0.286 | 0.333 | 0.400 |

Axes labelled

6 points plotted correctly

Straight line

Good fit

1. **Explain how your graph verifies Boyle’s law.**

A straight line through the origin verifies that pressure is inversely proportional to volume

1. **Describe how the student ensured that the temperature of the gas was kept constant.**

Release the gas pressure slowly, allow time between readings.

**2003 Question 2**

In an experiment to measure the specific latent heat of vaporisation of water, cold water was placed in a copper calorimeter.

Steam was passed into the cold water until a suitable rise in temperature was achieved.

The following results were obtained.

Mass of the calorimeter........................... = 73.4 g

Mass of cold water .................................. = 67.5 g

Initial temperature of water..................... = 10 °C

Temperature of the steam........................ = 100 °C

Mass of steam added ............................... = 1.1 g

Final temperature of water ...................... = 19 °C

1. **Describe how the mass of the steam was found.**

Final mass of (calorimeter + water + condensed steam) – Initial mass of (calorimeter + water)

1. Using the data, calculate a value for the specific latent heat of vaporisation of water.

(ml) steam + (mc∆ϑ) steam = (mc∆ϑ) water + (mc∆ϑ) cal

∆ϑwater = 90C, ∆ϑcal= 90C

∆ϑ) steam = 810C

Answer = 2.2 × 106 J kg-1

1. **Why is the rise in temperature the least accurate value?**

Read only to one significant figure {the concept of significant figures is not on the syllabus and shouldn’t have got asked. It hasn’t appeared since.]

1. **Give two ways of improving the accuracy of this value.**

Use a digital thermometer, use more steam, use less water, insulation, cover, stirring, steam trap

**2003 Question 3**

The following is part of a student’s report of an experiment to measure the focal length of a converging lens.

“I found the approximate focal length of the lens to be 15 cm.

I then placed an object at different positions in front of the lens so that a real image was formed in each case.”

The table shows the measurements recorded by the student for the object distance *u* and the image distance *v*.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *u*/cm | 20.0 | 25.0 | 35.0 | 45.0 |
| *v*/cm | 66.4 | 40.6 | 27.6 | 23.2 |

1. **How did the student find an approximate value for the focal length of the lens?**

Focus the image of a distant object on a screen.

The distance from the lens to screen corresponds to the focal length.

1. **Describe, with the aid of a labelled diagram, how the student found the position of the image.**

Set up as shown.

Adjust the position of the screen until a sharp image is seen.

1. **Using the data in the table, find an average value for the focal length of the lens.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *u*/cm | 20.0 | 25.0 | 35.0 | 45.0 |
| *v*/cm | 66.4 | 40.6 | 27.6 | 23.2 |
| f/cm | 15.4 | 15.5 | 15.4 | 15.3 |

1. 1/u+ 1/v = 1/f

Average **=** 15.4 cm

1. **Give two sources of error in measuring the image distance and state how one of these errors can be reduced.**

Image not sharp / parallax error in reading distance / not measuring to centre of lens / zero error in metre stick

4

In an experiment to verify Joule’s law, a heating coil was placed in a fixed mass of water.

The temperature rise Δθ produced for different values of the current *I* passed through the coil was recorded.

In each case the current was allowed to flow for a fixed length of time.

The table shows the recorded data.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *I* /A | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
| Δθ / °C | 3.5 | 7.0 | 10.8 | 15.0 | 21.2 | 27.5 | 33.0 |

1. Describe, with the aid of a labelled diagram, how the apparatus was arranged in this experiment.

See diagram below.

1. ****Using the given data, draw a suitable graph on graph paper and explain how your graph verifies Joule’s law.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *I* /A | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
| Δθ / °C | 3.5 | 7.0 | 10.8 | 15.0 | 21.2 | 27.5 | 33.0 |
| *I2* /A2 | 2.25 | 4.0 | 6.25 | 9.0 | 12.25 | 16.0 | 20.25 |

Label axes

At least 6 correct points

Straight line

Good fit

A straight line through origin shows that ∆ϑ ∝ I2 which verifies Joule’s Law.

1. **Explain why the current was allowed to flow for a fixed length of time in each case.**

You can only investigate the relationship between two variables at a time and time is a third variable.

1. **Apart from using insulation, give one other way of reducing heat losses in the experiment.**

Start with cold water, change the water for each run, use a lid, shorter time interval, polish calorimeter

**2003 Question** 5

|  |  |
| --- | --- |
| State Hooke’s law.  | Hooke’s law states that when an object is stretched the restoring force is directly proportional to the displacement provided the elastic limit is not exceeded. |
| What is the relationship between the acceleration due to gravity *g* and the distance from the centre of the earth?  | *g* is inversely proportional to d2  $g∝\frac{1}{d^{2}}$ |
| The diagram shows forces of 5 N applied to a water tap. Calculate the moment of the couple (torque) on the tap.  | Moment = force × distance = 5 × 0.06 = 0.3 N m |
| Which wave phenomenon can be used to distinguish between transverse waves and longitudinal waves?  | Polarisation |
| Sound intensity level can be measured in dB or dB(A). What is the difference between the two scales?  | The dB(A) gives extra weighting to the frequencies which the human ear is most sensitive to. |
| Calculate the critical angle for diamond. The refractive index of diamond is 2.4.  | n = 2.4 $n=\frac{1}{sin C}$ $\sin(C)=\frac{1}{n}$ $\sin(C)=\frac{1}{2.4}$ sin C = 0.417 C = $sin^{-1}0.417$ *C* = 24.62°  |
| What is the purpose of a miniature circuit breaker (MCB) in an electric circuit? | It behaves as a fuse and breaks the circuit when too large a current flows. |
| What is the photoelectric effect? | It is the emission of electrons from the surface of a hot metal due to electromagnetic radiation of a suitable frequency shining on it. |
| What is meant by nuclear fusion? | Nuclear fusion is the combining of two small nuclei to form one large nucleus with the release of energy. |
| Give one contribution made to Physics by either Paul Dirac or Nicholas Callan. | Dirac predicted antimatter. |

**2003 Question 6**

1. **Give the difference between vector quantities and scalar quantities and give one example of each.**

A vector has both magnitude and direction whereas a scalar has magnitude only.

1. **Describe an experiment to find the resultant of two vectors.**
2. Use cord to attach three weights to a central knot using either a force-table with pulleys as shown or alternatively using three newton-meters.
3. Adjust the size and/or direction of the three forces until the central knot remains at rest.
4. Read the forces and note the angles.
5. The sum of the components of any two of the forces along the axis of the third force can be shown to be equal in magnitude but opposite in direction to the third force.
6. **Calculate the distance travelled by the cyclist.**

The displacement is equivalent to one quarter of the circumference of a circle

= $\frac{2πr}{4}= \frac{2π(25)}{4}$ = 12.5π = 39.3 m.

1. **Calculate the displacement undergone by the cyclist.**

Using Pythagoras theorem: x2 = 252 + 252  x = 35.3 m. Direction is NW

1. **Calculate the force required to keep the wheelchair moving at a constant speed up the ramp.**

*{If the wheelchair is moving at constant speed then the force up must equal the force down. So to calculate the size of the force up, we just need to calculate the force down}*

F = mg $\sin(θ)$ = 900 Sin 100 = 156.3 N

1. **Calculate the power exerted by the person in the wheelchair if it takes her 10 s to travel up the ramp.**

$Power=\frac{work}{time}$ and work = force × displacement

$Power=\frac{force ×displacement}{time}=\frac{156.3 × 5}{10}$ = 78 W

**2003 Question 7**



1. **Describe an experiment to show that sound is a wave motion.**
* Walking slowly from X to Y, you will notice the loudness of the sound increasing and decreasing at regular intervals.
* This is because sound waves from the two speakers will interfere both constructively and destructively, along the path XY.
1. **What is the Doppler effect?**

The Doppler effectis the apparent change in the frequency of a wave due to the relative motion between the source of the wave and the observer.

1. **Explain, with the aid of labelled diagrams, how this phenomenon occurs.**

In this diagram the source is moving to the right while emitting the waves.

The result is that:

1. Ahead of the moving source, the crests are closer together than crests from the stationary source would be. This means that the wavelength is smaller and the frequency is greater.
2. Behind the moving source, the crests are further apart than crests from the stationery source would be.
3. This means the wavelengths are greater and therefore the frequency is less.
4. **Calculate the speed of the wave.**

 *v = fλ* *v =* (68000)(0.005) **=** 340 m s-1

1. **Calculate the distance of the bat from the wall.**

$speed=\frac{distance}{time}$ distance = (speed)(time) distance = (340)(0.02) = 6.8 m.

Divide by two to get the distance going one way only. Distance of bat from wall = 3.4 m.

1. **If the frequency of the reflected wave is 70 kHz, what is the speed of the bat towards the wall?**

*f’* = 70000 Hz

*f* = 68000 Hz

*c* = 340 m s-1

*{From the bat’s perspective the wall is sending out a wave at a frequency of 68 kHz (the frequency of the wave doesn’t change just because it was reflected).*

*Now because the bat is moving towards the source (the wall) we will need to use ‘minus’ rather than ‘plus’ in the formula.*

*This is also an example of where the concept of* ***relative*** *motion applies; rather than the source of the wave moving towards the observer (the bat), the observer in this case is moving towards the source)}*



 $70000\left(340-u\right)=23120000$

$23800000-70000u=23120000$ $23800000-23120000=70000u$

$6800000=70000u$ *u* = 9.71 m s−1

Alternatively we could have rearranged our formula at the beginning to give $u=\frac{f^{'}c-fc}{f^{'}}$ and then substituted in the values as required.

1. **Give two other applications of the Doppler Effect.**

Speed traps , speed of stars (red shift), landing aircraft, ultrasound (blood movement or heartbeat of foetus), weather forecasting.

**2003 Question 8**

1. **Define the unit of current, i.e. the ampere.**

The ampere is the amount of charge which, if flowing in two very long parallel wires one metre apart in a vacuum will experience a force of 2 ×10-7 N *per metre length*.

1. **Describe an experiment to demonstrate the principle on which the definition of the ampere is based.**
2. Connect two parallel conductors (aluminium strips will do nicely) in a circuit as shown.
3. Complete the circuit to switch on the current.

Result: The strips will either move towards each other or repel each other, depending on the direction of the currents. .



1. **Draw a graph to show the relationship between current and voltage for a metal at constant temperature**
2. **Draw a graph to show the relationship between current and voltage for an ionic solution with inactive electrodes**



1. **Draw a graph to show the relationship between current and voltage for a gas.**
2. **How would the graph for the metal differ if its temperature were increasing?**

If temperature was increasing it would no longer be linear; instead there would be a curve (similar to the VI graph for a filament bulb) because resistance would increase (see graph).

1. **How would the graph for the ionic solution differ if its concentration were reduced?**

The slope of the graph would be less (the resistance increases) due to less ions /charge carriers being present.

**2003 Question 9**

1. **List two properties of the electron.**

Negative charge, negligible mass, orbits nucleus, deflected by electric / magnetic field etc.

1. **Name the Irishman who gave the electron its name in the nineteenth century.**

George Stoney

1. **Give an expression for the force acting on a charge *q* moving at a velocity *v* at right angles to a magnetic field of flux density *B*.**

F = Bqv

1. **How much energy does the electron gain?**

*{the final kinetic energy gained by the electron is equal to the initial (electrical) potential energy.*

*The potential energy is given by the equation W = QV}*

W = (1.6 × 10–19)(4000) W = 6.4×10−16 J

1. **What is the speed of the electron at the anode?**

Kinetic energy = ½ mv2  6.4 ×10-16 = ½ (9.1 × 10-31)(v2)  v =3.75 × 107 m s-1

1. **Calculate the force acting on the electron.**

F = Bev = (5 × 10–2)(1.6 × 10–19)( 3.75 × 107)F **=** 3.0 ×10−13  N

1. **Calculate the radius of the circular path followed by the electron, in the magnetic field.**

$F=\frac{mv^{2}}{r}$ $r=\frac{mv^{2}}{F}$ $r=\frac{(9.1 × 10^{-31})(3.75 ×10^{7})^{2}}{3.0 × 10^{-13}}$  r = 4.3×10−3 m

1. **What happens to the energy of the electron when it hits the screen of the CRT?**

It gets converted to light.

**2003 Question 10 (a)**

1. **Leptons, baryons and mesons belong to the “particle zoo”.**

Give (i) an example, (ii) a property, of each of these particles.

LEPTONS; electron, positron, muon , tau, neutrino

Not subject to strong nuclear force

BARYONS; proton, neutron

Subject to all forces, three quarks

MESONS pi(on), kaon

Subject to all forces, mass between electron and proton, quark and antiquark

1. **Calculate the minimum frequency of the γ-ray photon required for this reaction to occur.**

*The energy associated with the gamma ray photon (E = hf) needs to be equal to the energy associated with 2 electrons (E = 2mc2)*

*hf* = *2mc2*

(6.6 × 10–34)(*f*) = 2(9.1 × 10–31)( 3.0 × 108)2

 *f* =2.5×1020 Hz

1. **What is the effect on the products of the reaction if the frequency of the γ-ray photon exceeds the minimum value?**

The electrons which were created would move off with greater speed.

There may also be more particles produced.

1. **Write a reaction that represents pair annihilation.**

e+ + e- → 2γ

1. **Explain how the principle of conservation of charge and the principle of conservation of momentum apply in pair annihilation.**

Charge:

The *net* charge of the electron and positron is 0, and there is no charge associated with the gamma ray photons.

Momentum:

The electron and positron are moving directly towards each other, so net momentum beforehand = 0, and afterwards the two photons move in opposite directions so net momentum after = 0.

**2003 Question 11**

1. **What is radioactive decay?**

Radioactivity is the breakup of unstable nuclei with the emission of one or more types of radiation.

1. **What is an isotope?**

Isotopes are atoms which have the same *atomic number* but different *mass numbers*.

1. **Apart from “carbon dating”, give two other uses of radioactive isotopes.**

Medical imaging, (battery of) heart pacemakers, sterilization, tracers, irradiation of food, killing cancer cells, measuring thickness, smoke detectors, nuclear fuel

1. **How many neutrons are in a 14C nucleus?**

Eight

1. **14C decays to 14N. Write an equation to represent this nuclear reaction.**

$$$$

1. **How much of a 14C sample remains after 11 460 years?**

11,460 years corresponds to two half-lives. After one half-life ½ remains; after two half-lives ¼ remains.

1. **Calculate the decay constant of 14C.**

$T\_{1/2}=\frac{ln2}{λ}$ $λ=\frac{ln2}{T\_{1/2}}$ $λ=\frac{0.693}{(5730)(365)(24)(60)(60)}$ T1/2 = 3.8×10−12 s-1

1. **Why does the 12C in dead tissue remain “undisturbed”?**

Carbon 12 is not radioactive so it doesn’t change in anything else.

**2003 Question 12 (a)**

|  |  |
| --- | --- |
| **Part (i)** | The *rate of change* of an object’s momentum is directly proportional to the force which caused it, and takes place in the direction of the force. |
| **Part (ii)***u* = 0*v* = 50 m s–1 *a* = ?*s* = 1500 m*t* = | *Anytime we use the equations of motion we always need to work in just one direction. In this case we are working with the vertical direction, so although the skydiver may have been moving horizontally when he jumped, his initial velocity in the vertical direction was 0.* *v*2 = *u*2 + 2*as*502 = 0 + 2*a*(1500)2500 = 0 + 3000*a*  a = 0.83 m s-2 *Note that the acceleration in this question is not 9.8 m s-2 because skydiving takes air resistance into account.* |
| **Part (iii)** | *F*net *= ma* F = (90)(0.83) = 75 N (downwards) |
| **Part (iv)** | Diagram, schematic  Description automatically generatedAir resistance = weight Therefore resultant force = 0  Therefore acceleration = 0 Therefore speed is constant |
|  |  |

**2003 Question 12 (b)**

1. **What is the difference between heat and temperature?**

Heat is a form of energy, temperature is a measure of hotness.

1. **Explain the underlined terms.**

An emf is a voltage applied to a full circuit.

A thermometric property is any property which changes measurably with temperature.

1. **Name a thermometric property other than emf.**

Length, pressure, volume, resistance, colour

1. **Explain why it is necessary to have a standard thermometer.**

Two different types of thermometer will give slightly different readings at the same temperature

**2003 Question** **12 (c)**

1. **State Coulomb’s law of force between electric charges.**

Coulomb’s law states that the force between two point charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

1. **Define electric field strength and give its unit.**

Electric field strength at a point is the force per unit charge at that point.

The unit of electric field strength is the Newton per Coulomb (NC-1).

1. **How would you demonstrate an electric field pattern?** 
2. Place two electrodes in a petri-dish.
3. Pour some oil into the petri-dish and sprinkle on some semolina powder.
4. Connect a high voltage source (about 2,000 volts) to the metal electrodes.

Result: The semolina lines up in the direction of the field, showing the electric field.

1. **Copy the diagram and show on it the direction of the electric field strength at Y.**

Arrow towards X

**2003 Question** **12 (d)**

1. **State the laws of electromagnetic induction.**

Faraday’s law states that the *size* of the induced emf is proportional to the rate of change of flux.

Lenz’s Law states that the *direction* of the induced emf is always such as to oppose the change producing it.

1. **Describe the current flowing in the circuit.**

Alternating current.

1. **If the switch at A is open, the magnet will take longer to come to rest. Explain why.**

There is no longer a full circuit, so even though there is an induced emf (potential difference) there is no (induced) current, therefore no induced magnetic field in the coil therefore no opposing force.