Higher Level Physics

Sample Paper A

Answers[1]

1. W + 3 + 4 + 5 = 5·4 + 8·8 $\Rightarrow$ W = 2·2

   To verify the principle take moments about any point.

   Precautions include: Level the stick or use very light strings.

   (i) Pulleys or spring balances.
   (ii) See Book.
   If the stick is not horizontal: The component of each distance would have the cosine of the angle that the stick makes with the horizontal common to all.

2. 17·2 L + 17·2 x 4180 x 12 = 93·6 x 390 x (25 − 11) + (198·4 − 93·6) x 4180 x 14
   Specific Latent Heat of fusion: L = 336116·2 = 340000 = 3·4 x 10^5 J Kg^{-1}

   Mass of ice = (mass of calorimeter + warm water + melted ice) − (mass of calorimeter + warm water)

   Warm water: Smaller heat loss and heat lost while above room temperature cancels heat taken in while below. If ice is wet then water is added to calorimeter and water.

3. Get square root of each T. Draw graph. Slope is about 107. *f* is proportional to square root of T.

   Mass: Use the usual formula and the slope = 1/ (2 L$\sqrt{m}$ $\Rightarrow$ *m)* = 4·23 x 10^{-5} Kg m^{-1}

   Natural frequency: Bang tuning fork. Place fork on bridge. Put more masses in the pan until the riser falls off.

4. Wire not of uniform cross-sectional area. Get an average value for the diameter, add all the values and divide.

   Add the five values: 1·69 Divide by 5: 0·338 Subtract the error: diameter = 0·318 mm; radius = 0·159 mm

   Resistivity of nichrome: $\rho = \dfrac{RA}{L} = \dfrac{8 \times \pi(0.000159)^2}{0.604} = 0.105{\times}10^{-5} = 1 \times 10^{-6}$ Ωm

   Resistance reading is only correct to <u>one</u> significant figure and so is least accurate. A more reliable method would be to use a metre bridge.

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5. (a) $10\sqrt{2}$ north–east.

   (b) $\omega = \pi$, $a = \omega^2 x = \pi^2 3 = 29.6$ cm s^{-2}

   (c) Yes. Density = 800 kg m^{-3} is less than water.

   (d) Lowest sound intensity that the human ear can detect.

   (e) 39°

   (f) Apparent change in frequency of a note when the source of sound is moving toward or away from the observer.

   (g) $C = \varepsilon A/d = 890$ nC

   (h) Rectification: a.c. $\rightarrow$ d.c.; Component: diode

   (i) When electromagnetic radiation is incident on a metal, and electrons are emitted.

   (j) Neutrino with zero charge.

   (k) base + collector = emitter.

6. Velocity after = 15 m s^{-1}.

   Energy = 0·16 >>> 0·055.

   Energy lost in reverting back to original shape, heat lost, sound given out.

7. Different values: Different thermometers have thermometric properties that do vary uniformly.

8. (a) $7·0 \times 10^{-5}$C   (b) (i) $V = RI \Rightarrow 9·6 = 16\,I \Rightarrow I = 0·6$ A ;

      (ii) $W = RI^2 = 16 \times 0·6^2 = 9·76$ W

9. (a) (i) $F = B\,I\,L = 0·44 \times 2·6 \times 0·2 = 0·2288 = 0·23$ N

      (ii) Take moment = force by distance from axis = $0·2288 \times 0·075 = ... = 0·017$ Nm

   (b) (i) Induced e.m.f. = rate of change of flux for one coil $4 \times 10^{-4} / 10^{-3} = 0·4$ V
          Induced e.m.f. for 200 coils = 80 V

      (ii) Voltage across the coil is 80 V and this opposes the 100 V. $\therefore 100 - 80 = 400\,I$;
          $I = 0·05$ A

10. (a) Kinetic energy of each of the particles produced: $E = hc/\lambda = 1·65 \times 10^{-13}$;
         2 electrons $\Rightarrow mc^2 = 1·638 \times 10^{-13}$. Subtract and half = 6×10^{-16} J
         Mass defect = $1·4 \times 10^{-29}$: $mc^2 = 1·26 \times 10^{-12}$ J = 7·875 MeV

OR

   (b) (i) Because of the stronger magnetic field it increases the self induction.
       (ii) Lenz's law implies it.
       (iii) Reduce energy losses in reducing the induced e.m.f.s.

11. (b) Becquerel...19th

(c) Z protons and A-Z neutrons

(d) To complete the final equation 3 alpha particles and 2 beta particles are emitted.

(f) 2 alpha particles. $^{226}_{88}Ra \Rightarrow {}^{222}_{86}Rn \Rightarrow {}^{218}_{84}Po$

(g) Different rates of disintegration

(h) $1 \cdot 35 \times 10^{-11} s^{-1}$

12. (a) Centripetal force : force towards centre, of object moving in a circular path

Calculate: $v = r\omega$ and $r = \frac{1}{2}(60) = 30$; $v = (30)(0.3) = 9 \text{ m s}^{-1}$; direction: west

(b) focal length = 80 and $\frac{80}{3}$.

(c) Spacing $= s = n\lambda/Sin\,\theta \Rightarrow (1)(5.2 \times 10^{-7})/Sin\,15 = 2 \times 10^{-6}$ m

Colours are seen on soap bubbles, etc. because of interference.

Calculate highest order: $Sin\,\theta\;n\,\lambda/d = (1 \times 5.2 \times 10^{-7}) \div 2 \times 10^{-6} = 0.2588$

If $n = 2$, $Sin\,\theta = 0.5176$; If $n = 3$, $Sin\,\theta = 0.7764$;

If $n = 4$, $Sin\,\theta > 1$, which is impossible;

$\therefore$ highest order = 3

(d) Name: Wilhelm Röntgen

X-ray tube: heated filament, electrons emitted, heavy metal target, anode, high voltage (e.g. 100 kV), vacuum, X-rays, lead shielding.

$K.E. = \frac{1}{2}mv^2 = eV = (1.6 \times 10^{-19})(120 \times 10^3) = 1.92 \times 10^{14}$ J

$$E_k = hf = hc/\lambda$$

$$\lambda = \frac{hc}{E_k} = \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{(1.92 \times 10^{14})} = 1 \times 10^{-11} \text{ m}$$

Higher Level Physics

Sample Paper B

Answers[1]

1. Plot F against a. A straight line through the origin verifies the law.
    Get slope = 0·38 = mass.

2. 1168 = 0·053 x 390 x 5 + 0·0896 x L x 5 $\Rightarrow$ L = 2376 = 2400 J Kg^{-1} K^{-1}
    Heat loss: Lagging, Cover, Heat quickly.
    Larger mass gives smaller rise in temperature. Percentage error greater.

3. Graph sin i against sin r. A straight line through the origin verifies the law.
    Graph gives slope 1·55 = μ = refractive index.
    Smaller distance $\Rightarrow$ greater percentage error.

4. Graph R against θ.

    (i) Produce back and get 4·1 Ω

    (ii) The slope = 0·016 ΩK^{-1}

    To measure resistance use an ohmmeter or metre bridge and to measure temperature use a thermometer.
    Heating the wire slowly gives the water time to convect.

5. (a) a = v^2/r = $(8 \times 10^6)^2$/5×10^{-10} = 1.28×10^{23}m s^{-2}

    (b) g = Gm/$_r{}^2$

    (c) prism and diffraction grating

    (d) T = (4)(15) = 60 N

    (e) μ = 1/Sin C = $\sqrt{2}$ or 1.414

    (f) Q = I t = 3(300) = 900 C

    (g) temperature control, fail-safe devise, measurement of unknown resistance. Any two

    (h) Any step-up example (e.g. TV, etc.); any step-down example (e.g. TV, radio, mobile phone charger)

    (i) E = h $\dfrac{c}{\lambda}$ = 3.96×10^{-19} J

    (j) $\dfrac{2}{3}, \dfrac{2}{3}, \dfrac{2}{3}, \dfrac{1}{3}, \dfrac{1}{3}, \dfrac{1}{3}$

    (j) Base + collector = emitter and base controls collector

6. Constant: 0.5g = $-$k 0.2 $\Rightarrow$ k = 2.5 g;
    Resultant force: 0.5a = $-$2.5gx; $\Rightarrow$ a = $-$49x $\Rightarrow$ s.h.m.

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Period: $T = \frac{2\pi}{7}$

Maximum speed: $v^2 = 2gh = 2 \times 9\cdot8 \times 0\cdot85 \times (1-\cos35) = 3\cdot0129$; $v = 1\cdot7$ m s^{-1}.

Not s.h.m. because angle > 5°

7. (i)   U-value = measure of energy escaping from a structure. U-value is decreased.
    (ii) Sea is shiny and so is better reflector.
    (iii) The heat of vaporisation is taken from the body to evaporate the perspiration.
    (iv) Water being a bad conductor does not conduct heat from top to the bottom.

8. Electric field intensity = Force on unit coulomb.

    Semolina in olive oil experiment with a positive and an equal negative charge.
    (i)   Use $E = \frac{Q}{4\pi\varepsilon r^2} = 9.9 \times 10^5$ N C^{-1} (ii)   Charge = $5\cdot87 \times 10^{-5}$ C

9. Alpha particle is a Helium nucleus.

    $^{14}_{7}N + ^{4}_{2}He \Rightarrow ^{17}_{8}O + ^{1}_{1}H$ or alpha particle. It was the first artificial **transmutation** of an

    element.

    Number of moles $= \dfrac{2 \times 10^{-6}}{226}$;

    Number of alpha particles $= \dfrac{2 \times 10^{-6}}{226}$ x $6\cdot02 \times 10^{23} = 5.33 \times 10^{15}$

    Number of alpha particles emitted per sec = $\lambda N = (1.35 \times 10^{-11})$
    $(5.33 \times 10^{15}) = 7.19 \times 10^4$

10. (a) $^{4}_{2}He + ^{4}_{2}He$ + energy.

         Historical significance is that it was the first **Fission** of a nucleus.

         mass defect = $1\cdot3323 \times 10^{-26} - 1\cdot3292 \times 10^{-26} = 3\cdot1 \times 10^{-29}$ kg $\Rightarrow$
         Energy = $3\cdot1 \times 10^{-29} \times 9 \times 10^{16} = 2\cdot79 \times 10^{-12}$ J

         (i) baryons = three quarks, antibaryon = 3 anti-quarks,
         (ii) meson = quark + anti quark.

         Proton = uud or neutron = udd. pion = π^+ = u$\bar{d}$.

OR

     (b)   Component: Diode facing to the right.

11. (a) With longitudinal, vibration is parallel to direction of motion, transverse is perpendicular.

    (b) Longitudinal.

    (c) Bell in vacuum experiment.

    (d) Bang tuning fork and hold it to the ear.

    (e) Diffraction.

    (f) Both increase.

    (g) A note is of one frequency whereas noise has many.

    (h) 1214 Hz and 850 Hz

12. (a) Expression: $F \propto m_1 m_2 / d^2$ or $F = G m_1 m_2 / d^2$

    Meaning: force increases as the square of the distance decreases,

    or $F \propto 1 / d^2$

    Periodic time: 1 year (or 365.25 days)

    Calculate: From the formula for periodic time $T^2 = 4\pi^2 R^3 / G M$, it follows that $T^2 \propto R^3$

$$\therefore T_J^2 \propto R_J^3 \text{ and } T_E^2 \propto R_E^3 \quad \Rightarrow \quad T_J^2 \div T_E^2 = R_J^3 \div R_E^3$$

$$\therefore T_J^2 \div T_E^2 = (5.2 / 1)^3 = 140.6$$

$$\therefore T_J \div T_E = \sqrt{140.6} = 11.9 \text{ years } (\approx 3.7 \times 10^8 \text{ s})$$

    (b) Virtual image: formed where rays appear to intersect or cannot be formed on a screen.

    Uses: dentist's mirror or shaving/make-up mirror or floodlights or projectors.

    (c) Current throught the bulb: $I = {}^W/_V = {}^{100}/_{220} = 0 \cdot 45$ A.

    The initial current is greater because the resistance is lower when cold.

    (d) What is: the release of electrons from the surface of a hot metal.

    Label: A = (heated) filament, B = cathode, C = anode, D = screen.

    Problem : Work done = kinetic energy gained $(W = Q V)$

$$\therefore W = Q V = e V = 1.6 \times 10^{-19} \times 7500 \quad \text{[Charge, } Q, = \text{electronic charge, } e]$$

    Kinetic energy gained, $E = 1.2 \times 10^{-15}$ J

    Application: television, computer monitor, cathode ray oscilloscope (ECGs).

Higher Level Physics

Sample Paper C

Answers[1]

1. Graph *p* against 1/*V*: A straight line throught the origin verifies the law.

    Pressure: Get slope from graph ≈ 4669. Get 1/31. Go to 1/31 on 1/V axis and get about 150 Pa.

2. Apparatus includes: Resonance tube, Cylinder of water. Fork. Metre stick.

    Steps: Get resonance.

    $v = 4f (x + 0.3d)$. Add 0.3 *d* (or 1.26) to each value of *x*. Get the reciprocal of each value of *f*. Plot $(x + 0.3 d)$ against $1/f$. Multiply the slope of this graph by 4.

    Speed of sound = 355 m s^{-1} approximately.

    Get slope ≈ 7264. Speed of sound = v = 298.

    Frequency is found on the fork.

3. A possible method: Spectrometer, Diffraction grating, Sodium lamp.

    1 λ = (1/300000) sin 10·6 = 613 nm.
    2 λ = (1/300000) sin 21.5 = 610 nm. Average = 612 nm.

    Values on right of central image larger because the reading 0·0 is not the true straight through position.
    Two other factors: Do any two adjustments.

4. Draw a graph of resistance against temperature. Use ohmmeter or metre bridge to measure resistance. Use a mercury thermometer to measure temperature.

    Go to 55ºC on the temperature axis and go to the graph and get about 200 Ω.

    Produce the graph on. Go to 35 Ω on resistance axis and get about 110ºC.

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5. (a) $19{\cdot}6$ m s^{-1}

(b) $1{\cdot}125$ m

(c) 1.34×10^{-7} N

(d) Transverse vibrate at right angles and longitudinal parallel to direction of motion.

(e) 200 Hz.

(f) $F = Bqv = 3.12 \times 10^{-11}$ N

(g) $\phi = BA = 8$ Wb

(h) They are the same potential.

(i) Switch must be connected in the live wire , when switch is open the appliance is disconnected from the live

(j) When an electron and positron collide, two gamma rays result, conserving momentum and energy.

(j) Laminate the core, good conducting wires, low hysteresis (soft iron core).

6. The upthrust = weight of liquid displaced = volume x density x g = $\frac{4}{3}\pi r^3 \, \rho_1 \, g$

The initial force = weight – upthrust = $\frac{4}{3}\pi r^3 \, \rho_s \, g - \frac{4}{3}\pi r^3 \rho_1 \, g = \frac{4}{3}\pi r^3 \, g(\rho_s - \rho_1)$

$\therefore \frac{4}{3}\pi r^3 \, g(\rho_s + -\rho_1) = \frac{4}{3}\pi r^3 \, \rho_s \, a \Rightarrow g \;\; (\rho_s - \rho_1) \; /\rho_s = a$

7. (i) The heat per second = mass x latent heat = $0.65 \times 10^{-3} \times 2.3 \times 10^6 = 1.5 \times 10^3$ W

(ii) Energy used per second = $0.1 \times 1.495 \times 10^3 = 149.5$ W

Heat supplied in 5 minutes = 149.5×300

Mass of air = 15.6×1.2

$mc\Delta\theta$ = heat

$15.6 \times 1.2 \times 10^3 \Delta\theta = 149.5 \times 300$

$\Delta\theta = 2.4^oC$

8. Real depth = apparent depth by refractive index = $1.5 \times {}^4\!/_3 = 2$ m.

Speed of light in water = $c/n = 3 \times 10^8 \div (4/3) = 2.25 \times 10^8$ m s^{-1}.

Use of a lens: Correction of long-sightedness and as a magnifying glass.

Two positions: *u* and *v* are interchangeable.

(i) distance between two positions = 4 cm

(ii) $1/f = 1/u + 1/v \Rightarrow 1/f = 1/10 + 1/6 \Rightarrow f = 3.75$ cm

minimum distance occurs when $u = v \Rightarrow 2/u = 1/f \Rightarrow u = 2f \Rightarrow u + v = 2f + 2f = 4f$

9. (a) (i) UV releases electrons; (ii) Below threshold frequency; (iii) Remove dirt, otherwise UV cannot penetrate; (iv) Intensity of light; (v) No free particles (electrons) available.

   (b) In X-rays, electrons produce radiation. In P.E. effect radiation releases particles. High energy electrons produce high frequency X-rays. Relatively lower frequency UV release electrons of lower energy.

   $V e = {}^{hc}/_\lambda \Rightarrow \lambda =$ $1{\cdot}2 \times 10^{-11}$ m $= 0{\cdot}012$ nm

10. (a) $E = mc^2 = 1{\cdot}660 \times 10^{-27}\ 9 \times 10^{16} \div (1{\cdot}602 \times 10^{-19}) = 931$ MeV

   Minimum energy: 3 pions converted to energy: $7{\cdot}482 \times 10^{-28} \times (2{\cdot}998 \times 10^8)^2 = 6{\cdot}725 \times 10^{-11}$; $\therefore 3{\cdot}362 \times 10^{-11}$ J

   Table: All, infinite; All, short range; Charged particles, infinite; Protons & neutrons and very short range.

   $uud \Rightarrow \dfrac{2}{3} + \dfrac{2}{3} - \dfrac{1}{3} = 1.$

   $\bar{u}\bar{u}\bar{d} \Rightarrow -\dfrac{2}{3} - \dfrac{2}{3} + \dfrac{1}{3}$

OR

   (b) Connect a small resistance in parallel.

   Connect a large resistance in series.

   Resistance of the coil: $R = \rho\ L/A = 54\ \Omega$.

   (i) $V = RI = 53{\cdot}925 \times 0{\cdot}002 = 1{\cdot}1 \times 10^{-1}$ Volts

   (ii) Using $V = RI$: $\Rightarrow 10 = (R + 53{\cdot}925) \times 0{\cdot}002$; $\Rightarrow R = 4946 = 4900\ \Omega$

   (iii) $1{\cdot}998\ R = 53{\cdot}925 \times 0{\cdot}002$; $\Rightarrow R = 0{\cdot}054\ \Omega$.

11. (a) Induced e.m.f.
    (e) The magnetic field decreases, there is high induced e.m.f. in the coil itself (self induction).
    (f) Magnetic field would not be very strong.
    (g) Smaller because of self induction.
    (h) $220 \times \sqrt{2} = 311$ V

12. (a) (i) K.E. at bottom = P.E. at top = m g h   = 4 x 9.8 x 0.1 = 3.92 J

(ii) ½ m v^2 = 3.92 $\Rightarrow$ v^2 = (3.92 x 2) ÷ 4 = 1.96 $\Rightarrow$

v = $\sqrt{1.96}$ = 1.4 m s^{-1}

(iii) momentum = m v = 4 x 1.4 = 5.6 kg m s^{-1}

(b) Stationary: when similar waves moving in opposite directions meet OR idea of nodes and antinodes

Harmonics: (integral) multiples of the fundamental frequency

Calculate: from node to node = half a wavelength $\Rightarrow$ 1st to 11th = 10 half wave-lengths = 5 λ

5λ = 1.12 m $\Rightarrow$ λ = 0.224 m

v = f x λ $\Rightarrow$ v = 1500 x 0.224 = 336 m s^{-1}

(c) A_____ r_____ <---------- B

Calculate (7): E = $(1/4\pi\varepsilon)$ Q / r^2 = $[1/(4 \times \pi \times 8.9 \times 10^{-12})]$ $(2 \times 10^{-6}/0.05^2)$

= 7.15 x 10^6 N C^{-1}

(d) Do the characteristic of semiconductor diode.

Higher Level Physics

Sample Paper D

Answers[1]

1. 1st velocity: $1.45/(2 \times 0.02) = 36.25$ cm s^{-1};

   2nd velocity: $4.35/(2 \times 0.02) = 108.75$ cm s^{-1};

   Acceleration $= (108.75 - 36.25)/(8 \times 0.02) = 453$ cm s$^{-2} = 4.53$ m s^{-2}

   Precaution: Tilt to eliminate friction.

2. Graph *V* against θ.

   Diagram: Ohmmeter or metre bridge and thermometer.

   Get slope $= 0 \cdot 036$ V K^{-1} gives the e.m.f. per degree rise in temperature.

3. Draw the graph of the reciprocals of the numbers given. Reverse the coordinates and plot them also. Find where the graph cuts axes. Average $= 0 \cdot 42$. Get reciprocal $= 2 \cdot 4$ cm.

   Draw a diagram and indicate *u* and *v*.

4. To show variation of voltage agalnst currrent in the diode: Do characteristic of diode.

   Resistor protects the diode.

   Reverse diode and put voltmeter across diode and milliameter.

5. (a) $\eta/4$ rad s^{-1}
   (b) $\rho\, g\, h = 98728$ Pa
   (c) electric motor, electrolysis
   (d) 60ºC.
   (e) Both decrease.
   (f) $200\sqrt{4} = 400$ Hz
   (g) $\frac{1}{2}CV^2 = 1.1 \times 10^{-3}$ J
   (h) Produce X-rays.
   (i) $3\alpha + 2\beta$
   (j) protons and neutrons
   (j) When either A is high or B is high or both are high.

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6. (a) (ii) 30 + 90 = 120 m

　　　(iii) 12 m s^{-1}

　(b) Mass of Saturn:

$$v_s = \sqrt{\frac{GM_s}{R}}; \quad v_e = \sqrt{\frac{GM_e}{R}}; \quad v_s = 10\, v_e; \quad \Rightarrow \sqrt{\frac{GM_s}{R}} = 10\sqrt{\frac{GM_e}{R}}; \quad m_s = 6.0 \times 10^{26} \text{ kg}$$

7. (a) Energy removed from fridge: The mass of air = 0.15 x 1.2 kg

　　　　　　　　　　　Heat = m c $\Delta\theta$ = $0.18 \times 1000 \times 16$ = 2880 J

　　　How long will it take to cool:　The heat taken out per minute

　　　　　　　　　　= 0.0023 x 2.5 x 10^5 J = 575 J

　　　Time taken to do this = $2880 \div 575$ = 5.0 minutes.

　(b) $\frac{5}{6}$V 1020 g = 500000 g;　V = 588·235 m^3;

　　　V 1020 = total mass = 600,000;
　　　Extra mass = 100,000 kg = 100 t

8. (a) (i) amplitude
　　　(ii) frequency

　　　　Sound intensity: $2.6 \times 10^{-3} \div (4\pi\,(8.6)^2)$ = 0.000002797 W m^{-2} = 2.8 x 10^{-6} W m^{-2}
　　　　Doubling the sound intensity $\Rightarrow$ sound intensity level increases by 3dB.

　(b) Apparent change in frequency.

　　　Doppler effect.

　(c) Gamma, X-rays, UV, Visible Light, Infrared, Microwaves, Radio.

　　　Velocity of light.

9. (b) (i) $\frac{1}{3}+\frac{1}{6}+\frac{1}{9} = \frac{11}{18} \Rightarrow \frac{18}{11}$; $\frac{1}{4}+\frac{1}{8} = \frac{3}{8} \Rightarrow \frac{8}{3}$; R = $\frac{142}{33}$ Ω

　　　(ii) 9 = $\frac{142}{33}$ I $\Rightarrow$ I = $\frac{297}{142}$ A

　　　(iii) V = $\frac{18}{11} \times \frac{297}{142} = \frac{243}{71}$V

　　　(iv) $\frac{243}{71}$ = 9I $\Rightarrow$ I = $\frac{27}{71}$A

10. (a) Mass defect = 0·000291 u; Energy = 4.34 x 10^{-14} J

   Neutrino was predicted. It has no charge and little mass.

   $(9·1093 \times 10^{-31}) \times 2 \times (2·9979 \times 10^8)^2 \div 1·6022 \times 10^{-19} = 1·02$ MeV

Up $+\frac{2}{3}$	down $-\frac{1}{3}$	charm $+\frac{2}{3}$	strange $-\frac{1}{3}$	top $+\frac{2}{3}$	bottom $-\frac{1}{3}$
$\bar{u}$ $-\frac{2}{3}$	$\bar{d}$ $+\frac{1}{3}$	$\bar{c}$ $-\frac{2}{3}$	$\bar{s}$ $+\frac{1}{3}$	$\bar{t}$ $-\frac{2}{3}$	$\bar{b}$ $+\frac{1}{3}$

   OR

   (b) Diagram: The brightness will decrease because the self induction in the coil is increased.

11. (g) $\frac{hc}{\lambda}$ = W + KE $\Rightarrow 6·63 \times 10^{-34} \times 3·0 \times 10^8 \div (2·4 \times 10^{-7})$ = W + 4·2 x 1·60 x 10^{-19})

   W = 1·5675 x 10^{-19} J = 1·6 x 10^{-19} J

   (h) h f_0 = W $\Rightarrow f_0$ = 2·36 x 10^{14} Hz

12. (a) Principle: total momentum before = total momentum after, provided no external forces
   Velocity up: Just after bouncing up, *u = ?, v = 0, a = − g, s = h*
   $v^2 = u^2 + 2as \Rightarrow 0^2 = u^2 - 2gh$ **OR** $mgh = ½ mu^2$,
   $\Rightarrow u = \sqrt{2gh}$
   $u = \sqrt{2(9.8)(0.4 \times 10^{-2})}$ = $\sqrt{0.0784}$ =   0.28 m s^{-1}
   Velocity down : velocity just before collision = *v, u = 0, a = 9.8, s = 2.5*
   $v^2 = u^2 + 2as \Rightarrow v^2 = 0^2 + 2(9.8)(2.5) = 49 \Rightarrow v = 7$
   (*v = u1* for the momentum equation below)
   $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$
   $\Rightarrow$ 200 x 7 + 0   =   200 (− 0.28) + 600 v
   $\Rightarrow$ 1456 = 600 v $\Rightarrow$ v = 2.4 m s^{-1}

   (b) Definition: ratio of charge to potential **or** C = Q/V and explain notation
   Uses: tuning radios, flash guns, smoothing, filtering, etc. Any two.
   Calculate capacitance: Capacitance = ε A / d
   = $(9 \times 10^{-12}) (12 \times 10^{-2})^2 \div (3 \times 10^{-3})$ =4.32 x 10^{-11} F
   Calculate energy: E = ½ C V^2 = ½ $(4.32 \times 10^{-11}) (180)^2$
                                           = 7 x 10^{-7} J

(d) X: Add two neutrons on r.h.s. i.e. $^{1}_{0}n + ^{1}_{0}n$:

Mass defect = 235·0439 − 235·8587 = 0·1939 u = 3·1874 x 10^{-28} kg

E = mc^2 = 3·1874 x 10^{-28} x (2·998 x $10^8)^2$ = 3·219 x 10^{-28} J

Higher Level Physics

Sample Paper E

Answers[1]

1. Do l.h.s =m_1u_1 ,   r.h.s = $m_1u_1+m_2u_2$ for each line

    0·2 x 0·2 ÷ 0·2 = 0·2,   0·42 x 0·2 ÷ 0·42 = 0·2;

    0·2 x 0·2 ÷ 0·14 = 0·29,   0·52 x 0·2 ÷ 0·36 = 0·29;

    0·3 x 0·2 ÷ 0·16 = 0·38,   0·72 x 0·2 ÷ 0·38 = 0·38

    Time can be measured on the ticker timer method by taking the time for 20 cm each side of collision.

    Precaution: Tilt the plane to eliminate friction.

2. M_{steam} L + M_{steam} W(drop in temp)= $M_{cal.}$C (rise in temp.) + M_{water}W (rise in temp.)

    2·4 L + 2·4 x 4180 x 71 = 105·2 x 390 x 11 + 123·6 x 4180 x 11;

    $\Rightarrow$ L = 2·3 x 10^6 J kg^{-1}

    More steam: Greater rise of temperature and so smaller percentage error.

    Cooling the water: Cool it faster. Also the heat lost while above room temperature cancels heat gained while below.

3. Draw a graph of *f* against 1/*L* and get straight line which verifies.

    Diagram: The length of the wire is distance between bridges.

    The investigation is the relation between frequency and length and not the added factor of tension.

    Bang tuning fork. Place leg of fork on sonometer. If the paper rider does not drop off move a bridge and repeat until it does.

4. First obeys Ohm's law. Second graph is curved because the resistance increases as the temperature increases.

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5. (a) $200 = 40 v \Rightarrow v = 5 \text{ m s}^{-1}$

    (b) $50 \cos 60 = 0 \cdot 5 \text{ N}$

    (c) Gets shorter.

    (d) $\frac{2}{15}$ cm or $0 \cdot 133$ cm behind the mirror.

    (e) The wavelength is doubled and thus the frequency is halved: 100 Hz

    (f) A compass points in a north-south direction in response to the earth's magnetic field.

    (g) Output = mgh/t = 1000 x 10 x 9·8 ÷ 5 = 19,600.
         Efficiency = 19,600 x 100 ÷ 30,000 = 65·3%

    (h) Number is proportional to intensity.

    (i) The force is at right angles to direction of motion and so moves in a circle.

    (j) Those particles produced in particle accelerators when bombarding with high energy protons.

    (j) There is force on a current carrying conductor in a magnetic field.

6. The period of such geostationary orbits is 24 hours.

    Expression for $g = {}^{GM}/R^2$

    Value for g = 6·673 x 10^{-11} x 5·977 x 10^{24} ÷ (6·378 x 10^6)^2 = 9·805 m s^{-2}

    The angular velocity: $\omega = 2\pi ÷ 86400 = 7 \cdot 27 \times 10^{-5}$ rad s^{-1};

    (i) weight = 5 g = 49·02 N;

    (ii) reading = $5g - mr\omega^2 = 48 \cdot 85$ N

7. Real images: rays intersect. Virtual images: rays do not intersect and so cannot be formed on a screen.

    Power of combination = $P_1 + P_2 = 0 \cdot 05 - 0 \cdot 025 = + 0 \cdot 025$.
    Primary colours: Red, blue and green.
    Secondary: Yellow, magenta and cyan or turquoise.

8. (a)   (i) $\frac{1}{R_p} = \frac{1}{300} + \frac{1}{700} = \frac{1}{210} \Rightarrow R_p = 210$;   Total R = 610; $6 = 610 \text{ I} \Rightarrow$

             I = 0·009836 A = 0·01 A

          (ii) $V_{AB} = 210 \times 0 \cdot 009836 = 2 \cdot 06557 \text{ V} = 2 \text{ V}$;

          (iii) I = 2·06557 ÷ 700 = 0·003 A

9. (i)   There is a rate of change of flux, i.e., lines of force are cut, so there is an induced e.m.f. and current flows.
    (ii) There is a rate of change of flux in both coils. If current tends to flow in direction, current will also tend to flow in the direction dc and so nothing happens.
    (iii) Flux = 4 x 0·02 x 0·01 = 0·0008 $\Rightarrow$ Rate of change of flux = 0·0008 ÷ 0·005 = 0·16 V = e.m.f.
    (iv) 0·16=10 I $\Rightarrow$ I = 0·016 A $\Rightarrow$ F = 4 x 0·016 x 0·02 = 0·00128 N $\Rightarrow$ W = 0·00128 x 0·01 = 1·28 x 10^5J

10. (a) Kinetic energy of alpha particle: Let V_r = velocity of radon and V_a = velocity of alpha: $M_r V_r = M_a V_a \Rightarrow V_r = {}^4/_{222} V_a$

   $$\frac{E_1}{E_2} = \frac{222}{4} \Rightarrow E_a = \frac{4}{226} \times 7.8 \times 10^{-13} = 1.38 \times 10^{-14} J$$

   $$udd = +\frac{2}{3} - \frac{1}{3} - \frac{1}{3}$$

OR

   (b) Last two lines are 0,1,0 and 0,0,0. A LED or bulb would detect output.

11. (a) Electrons are negatively charged. They orbit in the shells of atoms.
    (b) Thermionic emission
    (c) Most of the kinetic energy of the electrons is absorbed as heat.
    (d) Roentgen
    (e) Ionisation
    (f) Very short wavelengths because they result from displacing electrons in the inner shells of atoms.
    (g) Absorb X-rays and thus provide protection.
    (h) To penetrate deeply into the atoms of tungsten.

12. (a) Pressure: force per unit area
        Bends: Extra pressure on body, too much nitrogen is dissolved in blood **OR** nitrogen forms bubbles)
        Calculate pressure: p = ρ g h = (1.36 x 10^4) (9.8) (0.78)
        =   1.04 x 10^5 Pa

    (b) To slowly give out the heat during the day.

        RI^2t – m c $\Delta\theta$ = 5 x 4 x 600 – 0·1 x 4200 x 20 = 3600 J.
        Reduce energy loss by lagging.

(c) Explain   (i):   warm day $\Rightarrow$ layers of air **OR** speed of sound $\propto$ temperature
$\Rightarrow$ sound refracted upwards
cold night $\Rightarrow$ sound refracted downwards $\Rightarrow$ better heard

Explain   (ii):   sound travels better/faster through denser materials; **OR** in air, there may be obstacles in the way

Explain (iii):   Upper frequency limit audible to humans is 20 kHz. Dogs can hear much higher frequencies.

(d) (i): the bulb will NOT remain lighting; d.c. is blocked by a capacitor
(ii): the bulb will light; capacitors conduct a.c.

Higher Level Physics
Sample Paper F

Answers[1]

1. (i) area = 600 = distance.

    slope = 10 m s^{-2} acceleration.

    Results: Area under v/t curve = distance travelled and the slope = acceleration.
    Connection: Area under curve = 600 m

2. Get reciprocals. Plot. Find points where the line cuts the axes and average. Get reciprocal for focal length ≈ 7·01

    A second set can be found by reversing *u* and *v*.

3. Several readings are necessary because the wire is not uniform.

    To measure the diameter of the wire use a Micrometer screw gauge.

    How used: Get zero error. Place wire in it and close down. Read and adjust.

    Precaution: Stretch the wire but do not strain it and press it down on the metre stick.

    Calculations: d = 0·206 mm;   r = 0·000103 m;
    $$\rho = {}^{RA}/_L = 26\cdot4 \times \pi(0\cdot000103)^2 \div 0\cdot685 = 1\cdot3 \times 10^6 \ \Omega \ m.$$

    To measure the resistance use an ohmmeter or metre bridge.

4. Plot P against I^2 and get a straight line throught the origin – this verifies the law.

    Get slope = 8·1 Ω = resistance.

    If the temperature increased so would the resistance.

5. (a) 10 R

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(b) $F = PA = (1.01 \times 10^5)(3^2) = 9.09 \times 10^5$ N

(c) 4.266 x 10^{10} J

(d) 60 cm

(e) Q = I t = 4 x 300 = 1200 C

(f) Half the distance between the plates or double the area.

(g) In two long uniform wires a metre apart in a vacuum have a force of 2 x 10^{-7} N per metre of wire when 1 A is flowing in each wire.

(h) Detect broken bones. Treatment of cancer.

(i) 82,206

(j) Quark and anti-quark.

(j) Connect a small resistor in parallel.

6. (b) Maximum speed: $mv^2/_r = mg$: cancel mass; $v^2 = gr = 45$ x $9.8 \Rightarrow v = 21$ m s^{-1}

(c) Work = n mgh = 10 x 200 x 6 = 12000 J $\Rightarrow$ Power = 200 W $\Rightarrow$ efficiency = 50%

7. (a) Increase per degree = (35·6 − 6·8) ÷ 100 = 0·288.
Room temperature = 5·6 ÷ 0·288 = 19·4°C.

Length of air trapped: 60 x 0·288 + 6·8 = 24·1 cm

(b) Pressure: P x 20·5 = 1·02 x 10^5 x 20 $\Rightarrow$ P = 9·5 x 10^4 Pa

(c) Mass: M C (100 − 22) = 0·5 x (11C) x 2 $\Rightarrow$ 0·14 kg

8. (i) Modes of vibration whose frequencies are multiples of a fundamental frequency.

(ii) Quality is the number of harmonics present.
Calculate the angle between surface and the wavefronts:

$$\mu = \frac{\sin i}{\sin r} = \frac{c_1}{c_2} = \frac{f\lambda_1}{f\lambda_2}; \quad \frac{\sin 6.2}{\sin r} = \frac{1}{4.75} \quad \Rightarrow \quad \sin r = 0.5129 \Rightarrow r = 30.9°$$

Velocity of sound: 5 wavelengths = 0.85 m $\Rightarrow$ 1 wavelength = 0·17 m
$\Rightarrow$ v = 2000 x 0·17 = 340 m s^{-1}.

9. (a) Force on each electron:
F = B q v = 5 x 10^{-3} x 1·60 x10^{-19} x 2·5 x 10^7 = 2·0 x 10^{-14} N

Force is at right angles to direction of motion and so they move in a circle.

(b) Energy = 2·56 x 10^{24} x 200 x 10^6 x 1·6 x 10^{-19} = 8·19 x 10^{13} J

10. (a)   (i) Coulomb $\Rightarrow$ 1·602 x 10^{-19} x 1·602 x 10^{-19} ÷ (4π x 8·854 x 10^{-12} x 10^{-26}) =

$2 \cdot 307 \times 10^{-2}$ N

(ii) Gravitation $\Rightarrow 6 \cdot 673 \times 10^{-11} (9 \cdot 109 \times 10^{-31})^2 \div 10^{-26} = 5 \cdot 537 \times 10^{-45}$ N

Particle accelerators.

After collision more particles are produced.

Formula: $E = mc^2$

Minimum energy: $1 \cdot 673 \times 10^{-27} \times (2 \cdot 998 \times 10^8)^2 = 1 \cdot 503 \times 10^{-10}$ J

OR

(b)   (i)   Potential across resistor is $4 \cdot 3$: $4 \cdot 3 = R(0 \cdot 1) \Rightarrow R = 43 \, \Omega$.
    (ii)   LED would switch on and off as the diode would become alternately forward and reversed biased.
   (iii)   From C to B and from right to left through the output resistor.
          From A to B and from right to left through the output resistor.

11. (a) Diffraction grating.
     (b) Red because longer wavelengths suffer least refraction.
     (c) Red, green and blue. Yellow, magenta and cyan.
     (d) Colours that add up to white light. Red & Cyan, Blue & Yellow, Green & Magenta
     (e) Light of one colour like sodium
     (f) Red + Green = Yellow. Red + Blue = Magenta, Blue + Green = Cyan.
     (g) Black. Artificial lights do have all colours of the spectrum and so certain colours will not be reflected.
     (h) Use a spectrometer.

12. (a) When there is a small angle of swing (i.e. $\theta \leq 5\,^{\circ}$). Mass at end of spring, tide, prong of tuning fork, etc.
          T = time for one oscillation = 2/5 = 0.4 s
          $T = 2\pi/\omega \Rightarrow \omega = 2\pi/T = 2\pi/0.4 = 15.71$
          $a = \omega^2 s \Rightarrow a = (15.71)^2 (0.02) = 4.9$ m s^{-2}

     (b)   (i) White light is made up of many wavelengths. Each wavelength is deviated at a different angle according to the formula $n \lambda = s \, Sin\theta$. Thus, a whole spectrum is formed.
          (ii) $Sin\theta = n\lambda/s$. If s is reduced, θ increases $\Rightarrow$ the separation between the images increases.
         (iii) Maximum value of $\theta = 90^{\circ}$. $n \lambda = s \, Sin\theta \Rightarrow 2 \lambda_{max} = d \, Sin \, 90^{\circ} \Rightarrow \lambda_{max} = d/2$

(c) Filament bulb, gases and semiconductors are types of conducting media that do not obey Ohm's law.

(d) Imagine looking through the solenoid from the r.h.s.
   (i) Let current flow clockwise. As M approaches, there is r.o.c. of flux $\Rightarrow$ current induced anticlockwise in ring. Nothing happens while inside. Current is also induced anticlockwise when emerging.
   (ii) If a.c. then above in (i) will occur when current is clockwise. The reverse happens when the current anticlockwise.

Ordinary Level Physics

Sample Paper A

Answers[1]

1. Plot the points and draw the graph.

   Area = 300 = distance travelled.

   Slope = 5 = acceleration.

2. (i) Diagram including sheet of paper and glass block ray box or pins. Measure angle with protractor.
   (ii) Mark the angles.
   (iii) Do sin i / sin r for each: 1·52..,1·52..,1·51.., and average = 1·52.

3. (i) Plot resistance on the y-axis against temperature on the x-axis.
   (ii) About 4 Ω.
   (iii) 3·42 Ω.
   (iv) Oil

4. (ii) Move the bridges.
   (iii) A straight line shows f α 1 ∕ L.

5. (b) ½ (6) (8)^2 = 192 J
   (d) Evaporation in a fridge.
   (e) Large area in small mirror (always diminished), image remains erect, image never at infinity, etc. Any two.
   (f) complementary; magenta

6. Height = 25 x 2 − 4·9 x 4 = 30·4 m.

   As it rises to highest point the speed decreases.

   P.E. = K.E. = $\frac{1}{2}$ x 2 x 25^2 = 625 J;

   0 = 25 − 4·9 t $\Rightarrow$ t = 5·1 s = time to reach highest point = time to come down.

7. (a) (i) 80 x 4200 x 15 = 5040000 J
   (ii) m x 4200 x 42 = 80 x 4200 x 15 $\Rightarrow$ m = 28·6 kg

   (b) Pressure = force per unit area and the unit is the pascal or Pa.
   Pressure exerted by the water = 1600 x 9·8 ÷ 24 = 653·3 Pa.
   When air is pumped out of the container there is no pressure inside and the pressure of the air on the outside is so great the can will collapse.

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8. (a) Refractive index = 1·4.

  (b) (i) The number of waves that pass a point in a second.
     (ii) Hertz or Hz.
    (iii) Velocity = frequency x wavelength.
    (iv) Light travels much faster than sound **or** light waves are traverse,
             sound waves are longitudinal.
     (v) A wave where the direction of vibration is perpendicular to the direction
           in which the wave travels.

9. (a) 6 x 4 = 24 J

  (b) Q = CV = $1000 \times 10^{-6} \times 50 = 5 \times 10^{-2}$ C

11. (a) Negatively charged, located in the shells of atoms.
   (b) Thermionic emission.
   (c) Most of the K.E. is absorbed.
   (d) Rontgen
   (e) Ionisation, penetrating power.
   (f) Seeing broken bones.
   (g) Protection from the harmful rays.
   (h) To produce high speed electrons.

12. (a) Calculate (i) initial momentum = 8 x 3 = 24;
      final momentum = 8 x 19 = 152, $\Rightarrow$ change in momentum =128 N s
      Calculate (ii):
      Method 1: F = rate of change of momentum = 128 / 8 = 16 N
      Method 2: $a = (v - u) / t$ = (19 − 3) / 8 = 2; F = ma = 8 x 2 = 16 N
      Calculate (iii): $s = ut + \frac{1}{2}at^2 \Rightarrow s = 3 \times 8 + \frac{1}{2}(2)8^2 = 88$
      OR $s = \frac{1}{2}(u + v)t = \frac{1}{2}(3 + 19)8 = 88$
      W = Fs $\Rightarrow$ W = 16 x 88 = 1408 J

  (b) Characteristics :   pitch   loudness   quality
      Factors: frequency   amplitude   overtones
      Why: Upper frequency limit audible to humans is 20 kHz. Dogs can hear much
      higher frequencies.
      Explain: Constructive and destructive interference of sound waves from each
      prong of tuning fork.

  (c) (i) $\frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{1}{2}; \Rightarrow R = 1 + \frac{1}{2} = 1.5;$

     (ii) $\Rightarrow 6 = 1.5\, I \Rightarrow I = 4$ A

  (d) Divide by 4: 55·5 V

Ordinary Level Physics

Sample Paper B

Answers[1]

1. (iii) Get reciprocal of volume in each case and plot and draw and get a straight line. The conclusion is that pressure is inversely proportional to volume.

2. (iii) Use formula for each set: 4·94, 4·99, 5·05 ⇒ average = 5·0 cm

5. (a) Force by distance. Joule
   (b) Upthrust = weight of liquid displaced.
   (c) barometer; height
   (d) Frequency
   (e) Doppler effect
   (f) T = −39 + 273.15 = 234.15 K
   (g) $P = VI \Rightarrow I$ = 800/230 = 3.48 A. The 5A fuse is the *nearest* above this value.
   (h) Mechanical to electrical
   (i) Emission of electrons from negatively charged surfaces after an electromagnetic radiation falling on it.
   (j) 40 → 20 → 10 → 5 → 2·5 g ⇒ answer: 2·5 g

6. (a) Weight = 0·2 x 9·8 = 1·96 N.
      5·6 x 50 + 1·96 x 10 = 299·6 ≈ 300, 10 x 30 = 300

   (b) (i) Work = 1000 x 9·8 x 6 = 58800 J;
      (ii) Average power = work ÷ time = 5880 W
      (iii) Efficiency = $(^{5880}/_{10000})$ x 100 = 58·8%

7. (a) Temperature difference 18 − (−10) = 28ºC

      Temperature: Rise for one degree is 0·28. ∴ temperature = 14 ÷ 0·28 = 50ºC

8. (b) Use formula: $\frac{1}{10} + \frac{1}{v} = \frac{1}{6}$ ⇒ v = 7·5 ⇒ magnification. = 0·75

10. (b) Energy liberated = 8·63 x 10^{-30} x 9 x 10^{16} = 7·767 x 10^{-13} J

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11 (a) Diffraction grating
    (b) Red. Violet
    (c) Red, green and blue
    (d) Ones that mix to give white.
    (e) Light of one wavelength or colour.
    (f) Yellow
    (g) Black
    (h) Use a spectrometer.

12. (a) Bends: Extra pressure on body, too much nitrogen is dissolved in blood **OR** nitrogen forms bubbles.

    (b)

    Uses: storing charge, tuning radios, flash guns, smoothing, filtering, etc. Any two.

    $C = Q/V \Rightarrow C = (10 \times 10^{-6}) \div 9 = 1.1 \times 10^{-6}$ F or 1.1 μF

    (c) Application: television, computer monitor, cathode ray oscilloscope (ECGs), etc. Any two.

    (d) X = p-n diode/junction; Function: to allow current to flow in one direction only. Lamp does not light, p-n junction is reverse biased.
    When S is closed, the lamp lights, current can bypass p-n junction.

Ordinary Level Physics

Sample Paper C

Answers[1]

1. (ii) Crush and dry it on absorbent paper.
    (iii) Mass of calorimeter, Mass of calorimeter and water, Initial temperature of water.
    (iv) Mass of calorimeter and water and melted ice. Final temperature of water.
    (v)   Lag the calorimeter.

2. (ii) Tilt the plane.

    Draw the graph and get a straight line to show force is proportional to acceleration.

3. (ii) Sodium lamp.
    (iii) First order reading to right and left, second order reading to right and left.
    (iv) Get angle between first order readings and half it. Use formula 1 λ = d sin θ. Repeat for second order.
    (v)   Give adjustments to spectrometer.

4. The graph is curved. As temperature increases the resistance increases.

5. (a) One newton acting on 1 square metre i.e. 1 N m^{-2}.
    (b) Force. Mass
    (c) Resistance; increases.
    (d) The bricks will give out a lot of heat as they cool.

    (e) Length and tension i.e. f α $\frac{1}{L}$ and f α $\sqrt{T}$

    (f) Resonance
    (g) (i) Diverging, (ii) Converging
    (h) F = B I L
    (i) (i) infrared light , (ii) ultraviolet

    (j) E = mc^2

6. (i) 20 = 4·9 t^2 $\Rightarrow$ t = 2·02 s;

    (ii) v = 9·8 x 2·02 = 19·8 m s^{-1};

    The moon has an acceleration due to gravity less than that on Earth.

7. (a) Different values: The thermometic properties of the thermometers do not vary uniformly.

    (b) Room temp: The rise in temperature for 1°C is 0·45. Divide 0·45 into 27 and come with 60ºC.

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8. (a) Sound wave is longitudinal.
       (i) 0·1 m   (ii) 0·8 m
       (i) $v = f \lambda = 2(0·8) = 1·6$ m s^{-1} (ii) $f = 2$

10. (a) Complete the reaction by adding on: $^{4}_{2}\text{HE}$

11. (a) By friction or induction.
    (b) Coulomb
    (c) Force is proportional to the charges and inversely proportional to square of the distance between them.
    (d) (i) negative,
         (ii) positive
    (e) Material that carries charge e.g. any metal – iron.
    (f) Material that prevents flow of charge – rubber.
    (g) It leaks out into the air.
    (h) Charge builds up on the TV screen. Photocopiers make use of charge in transferring the toner.

12. (a) The rocket/jet fires a gas backwards; the rocket/jet then must get the same change in momentum in the forward direction to ensure that the total momentum before is equal to the total momentum afterwards.
    $$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$
    $$\Rightarrow 0 + 0 = 500(-0.9) + 0.75 v$$
    $$\Rightarrow 450 = 0.75 v \Rightarrow v = 600 \text{ m s}^{-1}$$

    (b) $n = \dfrac{4}{3} = \dfrac{Sin\ i}{Sin\ r} = \dfrac{Sin\ i}{Sin\ 30^{0}} \Rightarrow \dfrac{4\ Sin\ 30}{3} = Sin\ i \Rightarrow 0.6667 = Sin\ i \Rightarrow i = 41.81^{0}$