# Past Paper Solutions

# Solutions to SQA examination

## Higher Grade Physics

## 2000

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### Section A

| | |
|---|---|
| 1. **C** | 11. **A** |
| 2. **D** | 12. **B** |
| 3. **D** | 13. **A** |
| 4. **B** | 14. **D** |
| 5. **E** | 15. **A** |
| 6. **D** | 16. **C** |
| 7. **A** | 17. **C** |
| 8. **A** | 18. **E** |
| 9. **D** | 19. **B** |
| 10. **E** | 20. **C** |

### Section B

21.a.i. $V_{horizontal}=V_{resultant}x\cos 60^o$

$V=7x\cos 60^o$

$\mathbf{V_{hor}=3.5(m/s)}$

a.ii. $V_{vertical}=V_{resultant}x\sin 60^o$

$V_{ver}=7x\sin 30^o$

$\mathbf{V_{ver}=6.06(m/s)}$

b. The horizontal velocity throughout is constant. This fact can be used to calculate the time to reach the dish.

$t = s_{hor}/V_{hor}$

$t = 2.8/3.5$

**t = 0.8s**

c. $h = s_{vert} = ?$
$t = 0.8s$
$v_{vert} = +6.06m/s$
$a = -9.8m/s^2$

$s_{ver} = ut + 1/2(at^2)$
$s_{ver} = 6.06x0.8 + 1/2(-9.8x0.8^2)$
**$s_{ver}$ = 1.71m**

d. If the release point of the projectile is taken to be the ground line, this means it will have no potential energy at this height. The total energy on release is therefore all the kinetic energy.

$E_k(initial) = E_{total}$

At height h the total energy of the projectile is made up of potential energy($E_p$) and kinetic energy($E_k$).

$E_{total} = E_k + E_p$

The kinetic energy of the projectile as it enters the dish must, therefore, be **less** than that when it leaves the contestants hand.

22.a.i. **Using equations of motion**

| | |
|---|---|
| $u = 0m/s$ | $v^2 = u_{2_1}{}^2 + 2as$ |
| $a = -9.8m/s^2$ | $v_2{}^2 = 0^2 + 2x-9.8x-2$ |
| $s = -2m$ | $v^2 = 39.2(m/s)^2$ |
| $v = ?$ | **v = -6.26m/s** (negative indicates downward direction) |

**Using conservation of energy**

$E_p = E_k$
$mgh = mv^2/2$
$v^2 = 2gh$
v = SQRT(2gh)
v = SQRT(2x-9.8x-2)
v = SQRT(39.2)
**v = -6.26m/s** ...as before

a.ii. $F_{avg}$ = change in momentum/contact time
$F_{avg} = (mv-mu)/t$
$F_{avg} = m(v-u)/t$
$F_{avg} = 15(0-[-6.26])/0.02$
$F_{avg} = 4695N$

This is the force that decelerates the mass. The force exerted by the mass on the pipe is equal an opposite.

**$F_{avg}$ = -4695N**

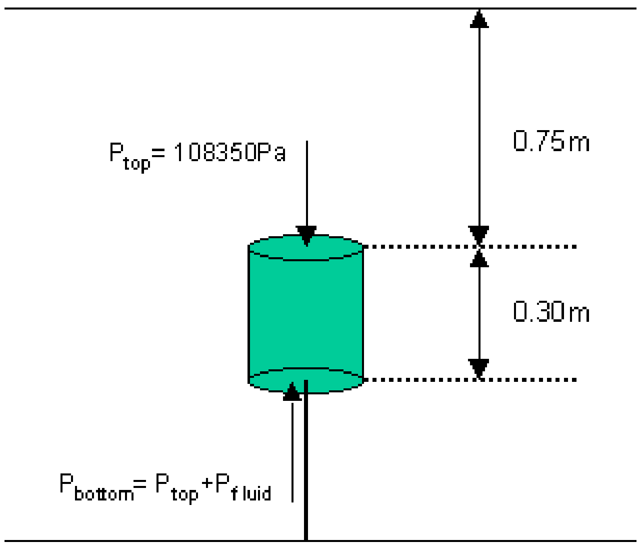
The negative sign indicates that the force acts in the downwards direction.

b. The thick layer of soft material will increase the time over which the momentum changes. As the change in momentum is the same, the average unbalanced force must be less.

c. Block X will cause more damage because the force, although the same for each block, is exerted over a smaller area. This results in more pressure applied to the pipe.

Pressure = Force/Area

23.a. The pressure on the lower surface is equal to that on the top surface plus the additional fluid pressure.



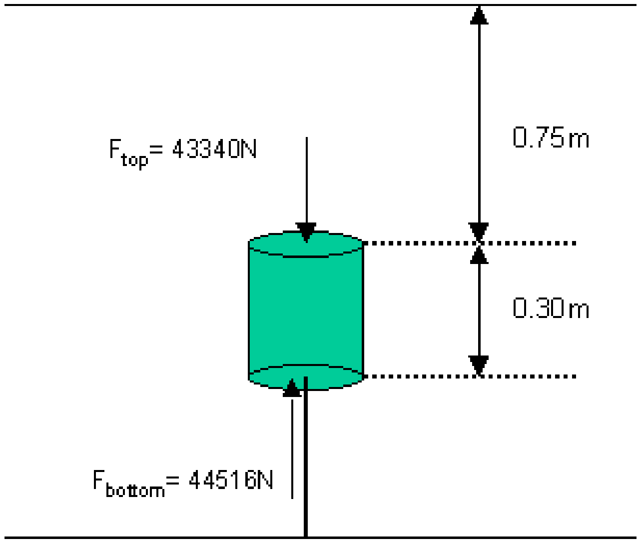

$P_{bottom} = P_{top} + \rho gh$

$P_{bottom} = (108350 + 1000 \times 9.8 \times 0.3)$Pa

$P_{bottom} = (108350 + 2940)$Pa

$\mathbf{P_{bottom} = 111290Pa}$

b.




$F_{upthrust} = F_{bottom} - F_{top}$
$F_{bottom} = P_{bottom}A$
$F_{bottom}$ = 111290x0.4 = 44516N

$F_{top} = P_{top}A$
$F_{top}$ = 108350x0.4 = 43340N

$F_{upthrust}$ = 44516-43340
**$F_{upthrust}$ = 1176N**

c. As the density of sea water is greater than that of fresh water, the additional pressure, due to the fluid, acting on the lower surface will increase. This will increase the upthrust.

24.a. To calculate the capacitance use the mean values of charge and voltage.

C = Q/V
C = (32/2.56)μF
C=12.5μF

The percentage error in capacitance value can be taken to be equal to that of largest individual percentage error.

% error in voltage = (0.01/2.56)x100 = 0.39%
% error in charge = (1/32)x100 = 3.125%

**C=12.5μF+-3.125%**
OR
3.125% of 12.5μF = 0.39μF
=> **C = (12.5+-0.4)μF**

NB/
Only quote the error to the same number of decimal places as the capacitance value.

b.i. The maximum energy is stored in the capacitor when the voltage across the capacitor is equal to the supply voltage.

$V_C = 12V$
$C = 2200x10^{-6}$
$E = ?$

$E = 1/2(QV_C)$
$Q = CV_C$
$=> E = 1/2(CV_C^2)$
$E = 0.5(2200x10^{-6}x12^2)$
**E = 0.1584J**

b.ii.(A) When the switch is opened the capacitor discharges through the resistor and relay coil. The discharge current magnetises the coil closing the switch in the lamp circuit, causing the lamp to light. As the discharge current gradually falls the coil loses its magnetism and the switch in the lamp circuit opens. When this happens the lamp goes off.

(B) Increasing the value of the capacitor increases the discharge time. The energy stored in the capacitor is also greater. This means that the lamp will stay lit for longer.

25.a.i. When used to produce a voltage the diode is said to be in **photo voltaic mode**.

a.ii. Light produces electron hole pairs in the depletion layer of the pn-junction.

a.iii. The voltmeter reading increases as the intensity of the light increases.

b.i. The emf is equal to the open circuit voltage.
emf = 0.508V

b.ii. $r = V_{lost}/I$
$r = (0.508-0.040)/1.08x10^{-3}$
$r = 0.468/1.08x10^{-3}$
**r = 433.3Ω**

Note: The answer to part (b.ii.) is too high to be realistic. For this reason a correction was made to the values used during the exam. However, the above answer does not use the corrected value.

c. Decreasing the value of the load resistor will increase the current in the circuit. This will increase the "lost" volts ($V_{lost}$=Ir).

Voltmeter reading = emf-$V_{lost}$

This explains the lower reading on the voltmeter when the switch is closed.

26.a.i. Period(T) = 4x2.5ms = 10ms
frequency(f) = 1/T

$f = 1/10x10^{-3}$
**f = 100Hz**

a.ii. $V_{peak}$ = 2x5 = 10V

$V_{rms} = V_{peak}/SQRT2$
$V_{rms} = 10/1.414$
$V_{rms} = 7.07V$

$I_{rms} = V_{rms}/R$
$I_{rms} = 7.07/200$
**$V_{rms} = 0.035A$**

b. The amplitude of the voltage across the resistor is reduced because there is a voltage drop across the diode. The negative half of the voltage cycle is removed because the diode only conducts when it is forward biased.

27.a. The intensity of radiation is equal to the incident **power per unit area**.
I = P/A

b. By keeping the light meter a constant distance from X you are justified in stating that any change in the recorded intensity is a result of changing $\theta$. If the distance was altered a change in intensity could be the result of a diverging beam.

c.i. The critical angle is found by noting the incident angle at which the reflected intensity reaches a maximum.
**$\theta = 42^o$**

c.ii. $n_{glass} = 1/\sin\theta_{critical}$
$n_{glass} = 1/\sin 42^o$
**$n_{glass} = 1.49$**

c.iii. The intensity of ray T will decrease as angle $\theta$ is increased upto $42^o$. At angles equal to and above $42^o$ the intensity of ray T will fall to zero, as the incident ray will be totally internally reflected.

28.a.i. Photoelectric emission is the term used to describe the process by which an electron bound in an atom can absorb enough energy from a single photon to escape, or be emitted, from the atom.

a.ii. **Threshold frequency**

a.iii. As the intensity of the radiation is increased there are more incident photons on the metal. Consequently, more electrons can absorb energy from the incident radiation. This will result in more emitted electrons which is consistent with the increased current.

28.b.i. $E_{photon} = hf$
$E_{photon} = 6.63x10^{-34}x9.0x10^{14}$
**$E_{photon} = 5.967x10^{-19}J$**

b.ii. $E_{total} = NE_{photon}$
$N = E_{total}/E_{photon}$
$N = 40.5x10^{-6}/5.967x10^{-19}$
**$N = 6.79x10^{13}$**

OR (If you like doing things the hard way.)

$I = P/A$
$I = (E_{total}/t)/A$
$I = (NE_{photon}/t)/A$
$\Rightarrow N = AIt/E_{photon}$
$\Rightarrow N = (1.8\times10^{-9}\times25\times15\times60)/ 5.967\times10^{-19}$
$\Rightarrow N = 4.05\times10^{-5}/5.967\times10^{-19}$
$\Rightarrow$ **$N = 6.79\times10^{13}$**

b.iii. The time taken for sunlight to erase the chip will be **greater**.
This is because only a proportion of the $25 W/m^2$ from sunlight is ultraviolet and it would therefore take longer for the semiconductor to absorb the required number of photons.

29.a.i. To calculate x and y use conservation of atomic and mass number.

**Atomic Number**
Total LHS = Total RHS
$88 = y + 2$
$y = 88 - 2$
$y = 86$

**Mass Number**
Total LHS = Total RHS
$226 = x + 4$
$x = 226 - 4$
$x = 222$

$^{222}_{86}\mathbf{Rn}$

a.ii. Energy is released in this reaction because the mass of the products is less than that of the radium nucleus.

a.iii. **Mass LHS**
$3.75428\times10^{-25}$ kg

**Mass RHS**
$(3.68771\times10^{-25} + 6.64832\times10^{-27})$ kg $= 3.7541932\times10^{-25}$ kg

Mass defect($\Delta M$) = Mass LHS - Mass RHS
$\Delta M = 3.75428\times10^{-25} - 3.7541932\times10^{-25}$
$\Delta M = 8.68\times10^{-30}$ kg

$E = \Delta MC^2$
$E = 8.68\times10^{-30}\times(3\times10^{8})^2$
**$E = 7.812\times10^{-13}$ J**

b. $Ek_{final} = Ek_{initial} + Ek_{gain}$

$Ek_{final} = 1/2[mv_{initial}^2]$
$Ek_{final} = 1/2[6.64832\times10^{-27}\times(1.5\times10^{7})^2]$

$Ek_{final} = 7.47936 \times 10^{-13}J$

$Ek_{gain} = qV$

q = charge on alpha particle = +2e = $2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}C$
V = accelerating potential difference = 25kV

$Ek_{gain} = 3.2 \times 10^{-19} \times 25000$

$\mathbf{Ek_{gain} = 8 \times 10^{-15}J}$

$Ek_{final} = 7.47936 \times 10^{-13} + 8 \times 10^{-15}$

$\mathbf{Ek_{final} = 7.55936 \times 10^{-13}J}$

**END OF QUESTION PAPER**

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