2022 C2 H2 Physics Prelim Exams Paper 1 Suggested Solutions

1	**D**	**6**	**B**	**11**	**B**	**16**	**D**	**21**	**C**	**26**	**C**
2	**B**	**7**	**A**	**12**	**D**	**17**	**D**	**22**	**A**	**27**	**B**
3	**B**	**8**	**C**	**13**	**B**	**18**	**C**	**23**	**C**	**28**	**D**
4	**B**	**9**	**B**	**14**	**B**	**19**	**C**	**24**	**A**	**29**	**B**
5	**B**	**10**	**A**	**15**	**C**	**20**	**A**	**25**	**D**	**30**	**D**

1 **D** 550 GHz = 5.50 x 10^{11} Hz

This corresponds to radiation with wavelength $\lambda = 3.0 \times 10^8/(5.50 \times 10^{11}) \approx 10^{-3}$ m

Wavelength of green light is of order of magnitude 10^{-7} m.

2 **B** Conceptual Question. Mean value should be close to the true value, while experimental values should have a large spread.

3 **B** The gradient of v-t graph give the acceleration, and initial gradient must be ½ of the original.

The area under the v-t graph gives the distance between the two train stations, so it must the same for the second train.

4 **B** By Newton's first law, the objects can continue at the state of constant velocity.

5 **B** $M_b u_b + 0 = M_b v_b + M_p v_p$

$(5)u_b + 0 = (5)v_b + (1)v_p$ (1)

$u_b - 0 = v_p - v_b$

$u_b = 3.33 - v_b$ (2)

Using (1) and (2) to solve for $u_b = 1.998\ m\,s^{-1}$

6 **B** Take moments about the pivot.

Torque = 5.0(2)(0.5 sin 40º) = 3.2 N m

7 **A** Consider the vertical component of the tension, and letting the angle that the cord makes with the metal sheet be θ,

2Tsin(θ) = 10 → sin(θ)=0.25 → θ = 14.5º

Length of cord required = 2(10/cos(θ)) = 20.7 = 21 cm

8 **C** Option A and D have the wrong units and can be ruled out immediately. Option B is wrong as *vt* does not give the total distance traveled as the object is not moving at constant speed.

9 **B** $a = \omega^2 r = \left(2\pi \times \frac{3000}{60}\right)^2 \left(\frac{8.0}{100}\right) = 7897 \approx 7900\ m\,s^{-2}$

10 **A** As the Earth is taken to be a uniform sphere, the gravitational potential at any point on the Earth's surface is the same (as $\phi = -\frac{GM}{R}$, where M is the mass of the Earth and R is the radius of the Earth), hence the gravitational potential energy of the Earth-rocket system is the same whether the rocket is near Equator or near the North Pole. As such the escape speed is the same whether the launch is near the Equator or near the North Pole.

11 **B** Those who chose C or D did not know that gravitational potential energy is negative. Those who chose A or C did not know that orbital radius is the sum of the radius of planet and altitude of the satellite.

12 **D** If both gases are at the same temperature, their average microscopic kinetic energy and root-mean-square speed will be the same.

Since the volume of container B is larger than that of A, the gas pressure and density will be smaller in B.

13 **B** Net work done on the gas = – |area enclosed| = – |area of circle| = $-\pi$ = – 3.14 J

By the first law of thermodynamics, there is a net heat transfer of 3.14 J into the system.

14 **B** The frequency of the driver determines the oscillating frequency.

So, f = 1/2 = 0.50 Hz

15 **C** Intensity of beam after passing Polaroid Q = $I\cos^2(30°)$

Intensity of beam after passing Polaroid R = $I\cos^2(30°) \times \cos^2(60°\text{-}30°)$ = 0.56 I (2 s.f)

16 **D**

$$Intensity\ I = \frac{P_{source}}{Area} = \frac{P_{source}}{4\pi x^2}$$ (As the source is a point source, the Area through which energy pass through is the surface area of a sphere with radius x.)

As P_{source} is constant, $I \propto \frac{1}{x^2}$

$$\frac{I_1}{I_2} = \left(\frac{x_2}{x_1}\right)^2 \Rightarrow \frac{I}{I_2} = \left(\frac{0.5x}{x}\right)^2 \Rightarrow I_2 = 4I$$

As $I = \frac{P_{received}}{Area_{reciever}}$

$P = IC$

$$P_{received\ 2} = I_2 \times Area_{reciever\ 2} = 4I \times 2C = 8P$$

17 **D** Using Rayleigh's Criterion

$$\theta_{min} = \frac{\lambda}{a}$$

If angular seperation of light sources θ is greater than θ_{min} , the two images will be resolved (distinguished on the screen).

To reduce θ_{min} , one can reduce λ or increase *a* so options A and C will help to distinguish the two images.

For option C, by reducing distance *D,* the actual angular separation of the light sources θ gets larger so it is larger than θ_{min} . This change also helps to improve the ability to distinguish the two images.

For option D, changing *L* has no impact on θ or θ_{min} so it is the correct answer.

18 **C** Note that the vertical nylon lines result in the horizontal diffraction images while the horizontal nylon lines results in the vertical diffraction images.

From the equation for diffraction grating, $d\sin\theta = n\lambda$

For monochromatic light of fixed λ, For the same order of maxima, when *d* is larger, sin*θ* is smaller and hence *θ* is smaller. This means that the separation of the straight through image and the image of the particular order is closer together.

Since the separation of the straight through image and the vertical images are smaller compared to the separation of the straight through image and the horizontal images, the *d* (slit separation) for the horizontal lines must be larger than the *d* for the vertical lines.

19 **C** Option A : $F = \frac{q^2}{4\pi\varepsilon_0 r^2}$. *r* decreases and hence, force increase. Option A is incorrect.

Option B : Electric field strength is a vector quantity. Sketching the individual *E* due to each charge at O and summing vectorially to find the resultant shows the *E* has decreased. Option B is incorrect.

Option D: Electric potential is a scalar quantity and hence resultant potential at O remains zero even when the change is made. Hence option D is incorrect.

Option C : $U = -\frac{q^2}{4\pi\varepsilon_0 r}$. *r decrease, U becomes more negative. Hence U decreases.* Option C is correct.

(Alternatively you can think of the fact that the charges being closer now experience a stronger attractive force and hence will be at lower potential energy and will require a greater amount of energy to separate them to infinity.)

20 **A**

$$E = -\frac{dV}{dx} = -(\text{gradient of } V - x \text{ graph})$$

Arrangement 1 : E-field is uniform and hence the gradient of *V-x* graph should be constant.

Arrangement 2 : E-field decreases as we move from P to Q, hence the gradient of *V-x* graph should be become gentler as we move from P to Q.

21 **C** Bulb X : $R_x = 10^2 / 20 = 5.0\ \Omega$

Bulb Y : $R_y = 5^2 / 2 = 12.5\ \Omega$

p.d. across X = 5.0 / (12.5 + 5.0) x 15.0 V = 4.3 V

power dissipated in X < 20 W

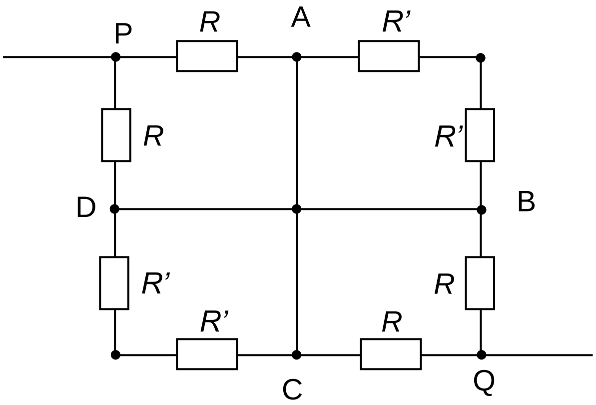
p.d. across Y = 12.0 / (12.5 + 5.0) x 15.0 V = 10.7 V

power dissipated in Y > 2 W

22 **A** $R = \frac{\rho l}{A}$ and $l\,A =$ constant

$R = \rho l^2$ / constant

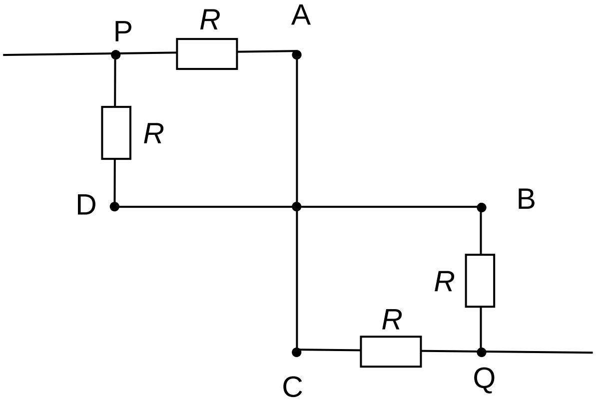
23 **C**



Points A, B, C and D have the same potentials.

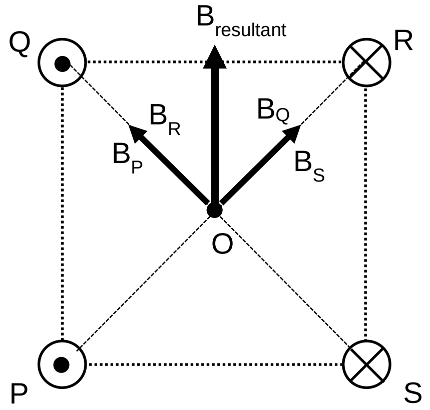
Thus, no current flows through all 4 R' resistors.

The above circuit can be re-drawn as shown below.



The effective resistance between P and Q is the twice of the net resistance of two resistors (across points P & D and P & A) in parallel. The effective resistance between P and Q = R.

24 **A** Apply RHGR to determine the direction of B-field at O due to the current flowing in a straight wire at P, Q, R and S respectively.



25 **D** Using a high direct current supply to coil X will result in high flux linkage in coil Y. But the flux linkage is not changing. Thus no e.m.f. will be induced in coil Y to produce a reading.

26 **C** For Loop 3 and loop 4, as the loops did not experience any change in magnetic flux linkage, there were no e.m.f. induced in loop 3 and loop 4. Thus no induced currents flow in loop 3 and loop 4 so the loops did not experience any magnetic force.

Loop 2 experienced a ***decreasing magnetic flux linkage*** through the loop, thus an e.m.f. is induced in the loop. As the loop is closed, an induced current flowed in loop 2. By Lenz's Law, the induced current in loop 2 flow in an anticlockwise direction to produce an effect to oppose the decreasing magnetic flux linkage. Thus by FLHR, there is a downward force on loop 2. (Or By Lenz's Law, there will be a downward force on loop 2 such as to produce an effect to oppose the decreasing magnetic flux linkage)

Loop 1 experienced an ***increasing magnetic flux linkage*** through the loop, thus an e.m.f. is induced in the loop. As the loop is closed, an induced current flowed in loop 1. By Lenz's Law, the induced current in loop 1 flow in a clockwise direction to produce an effect oppose the increasing magnetic flux linkage. Thus by FLHR, there is an upward force on loop 1. (Or By Lenz's Law, there will be a upward force on loop 2 such as to produce an effect to oppose the increasing magnetic flux linkage)

27 **B** When current is forward bias for the single diode, the total resistance is 1 kΩ. The peak current = peak voltage / 1 kΩ.
When current is forward bias for the single diode in series with the 5 kΩ resistor, the total resistance is 6 kΩ. The peak current = peak voltage / 6 kΩ. This is smaller than the previous case and the direction is opposite.

28 **D** Largest x-ray photon energy released $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(0.02 \times 10^{-9})} = 9.945 \times 10^{-15}\,J$

For the electron to release this photon energy, it need to get eV amount of energy from the accelerating field.

$(1.6 \times 10^{-19})V = 9.945 \times 10^{-15}$

$V = 62\,000$ volt

29 **B** ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{90}_{36}Z + 2\left({}^{1}_{0}n\right)$
Proton number = 36
Number of neutrons = 90 - 36 = 54

Count rate for 10 g of living wood = 200 per minute

30 **D** The count rate will be 50 after 2 half-lives.