PHYSICS

Unit 1 – Written examination

2023 Trial Examination

SOLUTIONS

AREA OF STUDY 1 – HOW ARE LIGHT AND HEAT EXPLAINED?

Question 1 (1 mark)

Answer: C

Explanation:

All electromagnetic waves as transverse waves travelling at the same speed, *c*, in a vacuum as distinct from mechanical waves that require a medium to propagate. The electric and magnetic field vectors are perpendicular to each other and at the same time are perpendicular to the direction of propagation of the wave which makes it transverse. Its speed is dependent on the refractive index of different mediums.

Question 2 (1 mark)

Answer: A

Explanation:

Hot air will always rise. When the air molecules gain heat energy, they begin to vibrate, collide with each, expand, and bounce around. Heat energy in converted to kinetic energy so particles gain speed. Increasing the air temperature inside the balloon envelope makes it less dense than the surrounding cold air. Since this air is less dense it rises pushing the air balloon up.

Question 3 (1 mark)

Answer: B

Explanation:

$\lambda_{max} T = 2.898 \times 10^{-3}$

$\lambda_{max} = \frac{2.898 \times 10-3}{16+273}$

$= 1 \times 10^{-5}$ m
$= 10\ \mu$ m

Question 4 (9 marks)

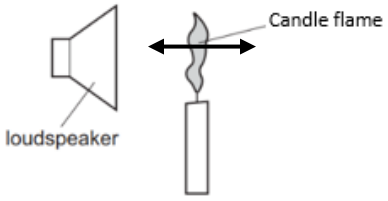
a. i. Peak to Peak = 2 x amplitude
2 = 2 x amplitude
Amplitude = 1 m (1 mark)

ii. Dugout canoe length = 25m
This length coves crest to tough = ½ λ
25m = ½ λ
λ = 25 x 2 = 50 m (2 marks)

iii. 14 waves pass in 7 minutes
1 wave will pass in $\frac{7}{14}\ min$ = ½ minute = 30 seconds
Frequency, f = $\frac{1}{T}$ = $\frac{1}{30}$ = 0.03 Hz (2 marks)

iv. speed, v = f λ = $\frac{1}{30}$ x 50 = 1.67 ms^{-1} (1 mark)

b. i.



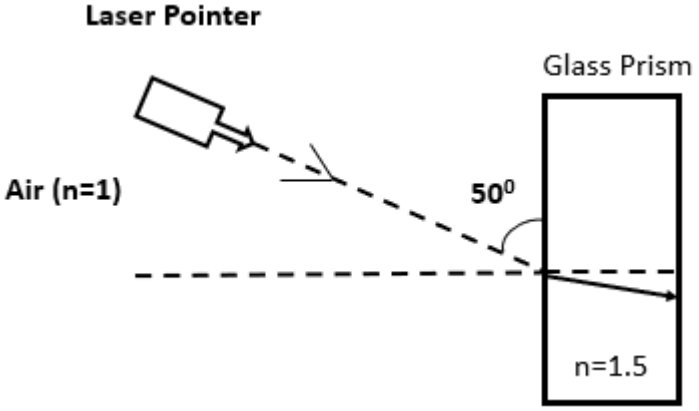
(1 mark)

ii. Longitudinal (1 mark)

c. UV, visible and infrared **(**1 mark)

Question 5 (10 marks)

a. i.



(1 mark)

ii. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

(1) sin 40 = 1.5 sin θ_2

θ_2 = $\sin^{-1}(\frac{sin\ 40}{1.5})$

θ_2 = 25.63^0 (2 marks)

b. The misconception is in the explanation statement where the student states that the frequency also changes. This is incorrect as frequency is constant. Frequency is determined by the light souce which is the lazer and this source does not change. The wavelength changes due to the change in speed as it eneters a medium of different refractive index.

(2 marks)

c. This is the critical angle

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

(1.5) sin θ_c = (1) sin 90^0

θ_2 = $\sin^{-1}(\frac{1}{1.5})$

θ_2 = 41.81^0 (1 mark)

d. Light must eneter from a more dense medium to a less dense medium

The angle of incidence must be greater than the crtical angle (2 marks)

e. UV - Security purposes, Example marking on banknotes and other objects

Gamma – Radiotherapy for killing cancer cells / Sterilising food and medical equipment

(2 marks)

Question 6 (8 marks)

a. When the air inside the oven is heated it travels away from the hot stones carring the thermal energy along. As temperature of the given fluid mass increases, the volume of the fluid must increase by same factor. This effect on the fluid causes displacement. As the immediate hot air rises, it pushes denser, colder air down. This series of events represents how convection currents are formed.

(1 mark)

b. The hot water at the bottom is less dense than the cold water on top so it rises. This allows cold water to fall down to come in contact with the heating element. This sets us convection currents where energy is transferred form the hesting element to all the water till it reaches boiling boint. (2 marks)

c i. $Q = mc \Delta T$

$= (2)\ (4200)\ (100 - 21)$

$= 663.6$ kJ (2 marks)

ii. $H = mLv$

$= (2)\ (2.27 \times 10^6$

$= 452000$ J

$= 452$ kJ (1 mark)

d. An increase in the atmospheric temperature causes more vaporisation which leads to more presence of water vapour particles in the atmosphere. The water vapour absorps the infrared radiation and then re-emitts it back to earth in the form of heat waves. This heats the earths atmoshpeer more causing more water to evaporate and the cycle continues. (2 marks)

AREA OF STUDY 2 – HOW IS ENERGY FROM THE NUCLEUS UTILIZED?

Question 7 (1 mark)

Answer: A

Explanation:

The source of solar energy is nuclear fusion where protons of hydrogen atoms violently collide in the sun's core and fuse to create a helium atom. This reaction produces enormous amount of energy.

Question 8 (1 mark)

Answer: C

Explanation:

Barium has an atomic mass of 137.3 so its mass number is 137.

Question 9 (1 mark)

Answer: B

Explanation:

$E = mc^2$

$3.9\ \text{Mev} = (3.9 \times 10^{6})(1.6 \times 10^{-19}) = 2.4336 \times 10^{-13}\ \text{J}$

$2.4336 \times 10^{-13} = m\ (3 \times 10^{8})^2$

$$m = \frac{2.4336 \times 10^{-13}}{(3 \times 10^{8})2} = 6.93 \times 10^{-30}\ kg$$

Question 10 (10 marks)

a. There are repulsive electrostatic forces between the two positively charged protons inside the nucleus. These forces are overcome by an even stronger attractive force between the protons and neutrons known as the strong nuclear force. This force binds the protons and neutrons inside the nucleus. Now these nucleons are so close that the attraction of the strong nuclear force outweighs the repulsive force between protons which ensure stability of the Helium -4 isotope.

(3 marks)

b. i. Half-life – describes the time taken for half of the atoms in a given mass of the radioisotope to decay.

OR. The time taken for half of the group of unstable nuclei to decay (1 mark)

ii. 6 hours = ½

12 hours = ¼

↓

36 hours = $\frac{1}{64}$

Or find the half -life = 36/6 = 6 hours

$(½)^6 = \frac{1}{64}$ (2 marks)

c.

Property	Radiation Type
No mass	**Gamma**
Charge of +2	**alpha**
Emits positron	**Beta^{+}**
Neutrons decay into a proton	**Beta^{-1}**

(2 marks)

d.

$^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + \boxed{{}^{4}_{2}\alpha} + \text{Energy}$

(1 mark)

$^{11}_{6}\text{C} \rightarrow {}^{11}_{5}\text{B} + \boxed{{}^{0}_{-1}e} + \text{Energy}$

(1 mark)

$^{99m}_{643}\text{Tc} \rightarrow {}^{99}_{43}\text{Tc} + \boxed{\gamma}$

(1 mark)

Question 11 (11 marks)

a. i. Decay series – sequence of decay stages that a radioisotope passes through to transform into a more stable isotope. (1 mark)

ii. 5 alpha decays (1 mark)

b. i. *Absorbed dose* = $\frac{Energy\ absorbed}{mass}$

$= \frac{0.072}{80} = 9\ x\ 10^{-4} Gy$ (1 mark)

ii. *Equivalent dose (Sv) = absorbed dose x quality factor*

$= 9\ x\ 10^{-4}$ x 15

= 0.0135 Sv (1 mark)

c. *Sv = Absorbed dose* x *quality factor*

$= 9\,x\,10^{-4}$ x 1 $= 9\,x\,10^{-4}$

(3 marks)

The damage will be decreased. Alpha particles are stopped in a short distance and release all their energy within this short span. This causes 15 time more damage than the x-rays. X-rays are more penetrating, so they distribute their energy to a larger area thus the damage is contained.

d. Radioisotopes are introduced to the body and the cancerous cells absorb these energies from these radioactive substances. Due to this energy being ionizing, it causes the cancerous cells to break down and die out.

Some common side effects are fatigue, poor appetite, mild abdominal pain, and nausea.

(3 marks)

Question 12 (8 marks)

a. Nuclear energy is the energy resulting from the conversion of mass where the lost mass is converted to energy (2 marks)

b. i. Fission chain reaction (1 mark)

ii. carbon or graphite (1 mark)

iii. increase the proportion of the free neutrons by a process called enrichment.

OR increase the concentration of the fissile isotopes (1 mark)

c. i. Iron, Fe (1 mark)

ii.

Nucleus	**Nuclear Reaction**	**Stability**
$^{3}_{2}\mathbf{He}$	Fusion / Fission	stable / unstable
$^{120}_{50}\mathbf{Sn}$	Fusion / Fission	stable / unstable

(2 marks)

AREA OF STUDY 3 – HOW CAN ELECTRICITY BE USED TO TRANSFER ENEREGY?

Question 13 (1 mark)

Answer: B

Explanation:

25 c = 1 kwh
4000W = 4kw = 25 x 4 = 100 cents
In 2 hours = 200 cents = $2.00

Question 14 (1 mark)

Answer: B

Explanation:

The residual current device is useful only when the current flows to earth, not if the current flows through the person between the active and neutral wires.

Question 15 (1 mark)

Answer: C

Explanation:

$I = \frac{P}{V} = \frac{300+1500+1000+315+60}{230} = 13.8$ A

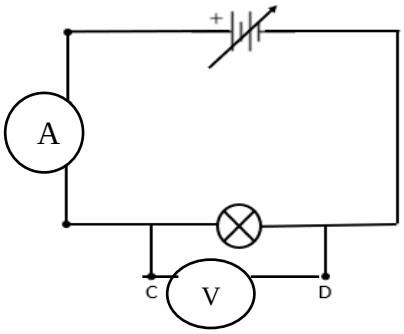
So, a 14 A fuse is suitable.

Question 16 (9 marks)

a. i. $n_e = \frac{Q}{q_e} = \frac{(5)(140)}{1.6\,x10^{-19}} = 4.38\,X\,10^{21}$ electrons (2 marks)

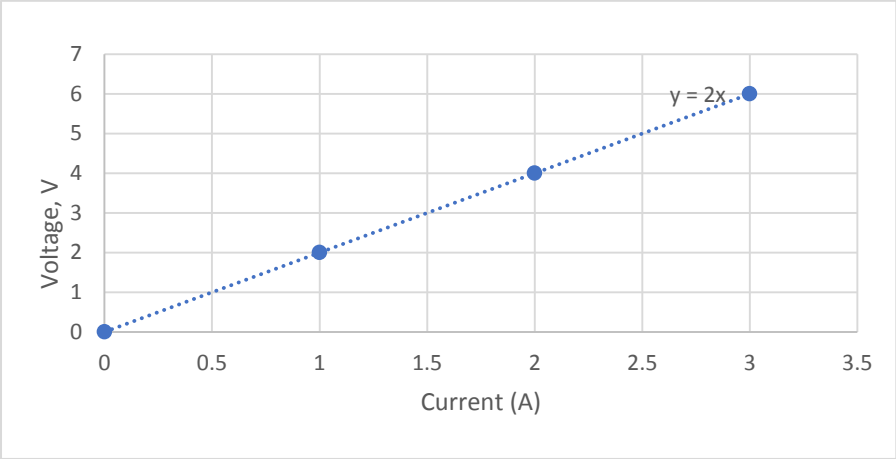
ii. E = VQ = (12) (5)(140) = 8400 J (1 mark)

b.



(2 marks)

c. i.



(1 mark)

ii. Gradient is $\frac{6}{3}$ = 2 VA^{-1} or 2 Ω (1 mark)

iii. This represents the resistance, *R*. (1 mark)

Question 17 (9 marks)

a. i Total resistance for the two parallel resistors: $\frac{1}{R_{(8\ \&12)}} = \frac{1}{8} + \frac{1}{12} = \frac{5}{24}$ thus $R = 4.8\ \Omega$

Effective resistance, $R_T = 4.8 + 5 = 9.8\ \Omega$ (2 marks)

ii. $V_{total} = I_{Total}\ x\ R_{Total}$

$30 = I_{Total}\ x\ 9.8$

$I_{Total} = \frac{30}{9.8} = 3.06\ A$

Current through the 5Ω resistor = 3.06 A

$V_{5\Omega}$ = IR = (3.06) (5) = 15.3 V (2 marks)

iii. $V_{12\Omega} = 30 - 15.31 = 14.7$ V

$I_{12\Omega} = \frac{14.69}{12} = 1.22\ A$ (2 marks)

b. i. Potentiometer / variable resistor (1 mark)

ii. The potentiometer consists of a fixed resistor that can slide up and down varying the amount of resistance. At a low resistance, the voltage and current increase, giving a rise in the output power. This increases the brightness of the LED. At a high resistance the LED will be dim.

(2 marks)

Question 18 (9 marks)

a. i It is a negative temperature coefficient thermistor because as the temperature increases, the resistance of the thermistor decreases. Inverse relationship between the temperature and resistance. (1 mark)

ii $I = \frac{V}{R_T} = \frac{20}{(20+10)\ x\ 10^3} = 6.67 \text{ x } 10^{-4}$ A (2 marks)

b. i. Diode (1 mark)

ii. LED's can operate with very small currents / takes up less space/produces very little thermal energy/ relatively long life-span

(1 mark)

c. i. RMS means root mean square which is equivalent to DC. So, 230 V_{RMS} means that the AC supply is equivalent to a steady 230V DC. (1 mark)

ii. To allow lights and appliances to be controlled independently of each other. Also allows multiple circuits within the same house to be regulated via fuses or RCD's. OR The current through devices wired in parallel is also lower compared to in series, reducing power loss and the risk of overheating.

(1 mark)

d. i. green/ yellow or a combination of green and yellow strips (1 mark)

ii. It acts as a safety mechanism. If the active wire becomes loose and touches the metal case, the current will flow through the Earth wire to the ground. Without the earth wire the toaster will become a live circuit and touching this can cause severe damage to the body or can even cause death. (1 mark)