S5 MARKING GUIDE 2023-2024

1.	**suggested answers:** In the photoelectric effect, the photons have only a few eV of energy, whereas in the Compton Effect, the photons have more than 1000 times greater energy and a correspondingly smaller wavelength. Also, in the photoelectric effect, the incident photons kick electrons completely out of the material and the photons are absorbed in the material while the electrons are detected and studied, whereas in the Compton Effect, the incident photons just knock the electrons out of their atoms (but not necessarily out of the material) and then the photons are detected and studied.	
2.	**(a)** FALSE **/1mk** **(b)** TRUE **/1mk**	
3.	**(a)** No. There are more photoelectrons, but the energy distribution, most specifically including the max energy, is unchanged. **(b)** Yes. Higher frequency means higher photon energy. Photon = hf. **(c)** No. Longer λ means lower frequency. **(d)** No. A larger work function means more photon energy goes into freeing the electron, so less is left over for its Kinetic energy (KE).	
4.	**(a)**For stationary waves, the position at which the two waves cancel is called a node… **/1mk (b)** Diffraction.is one of the properties of waves **/1mk** **(c)** The disturbance moving from one point to another is called the progressive wave **/1mk**	
5.	**(b) E=2.55 10^{-19} J /1mk**	
6.	a)Given: wavelength, ƛ=0.090nm, me=9.1x10^{-31}kg , angle θ=180^0 , Planck's constant=6.6x10^{-34}Js, speed ,c=3x10^8m/s Asked: magnitude of momentum of the scattered photon, P' We use the following relation describing Compton effect ƛ'-ƛ=h/mc (1-cosθ) , m is the mass 0f electron, ƛ is the wavelength of the incident radiation and ƛ' is the wavelength 0f the scattered radiation. ƛ'=ƛ+h/mc (1-cosθ) $\lambda' = 0.090 + \frac{6.626x10^{-34}}{9.1x10^{-31}x3x10^{8}}(1-\cos 180) = 94.85x10^{-12}\,m$ P'=-h/ƛ' $p' = \frac{-6.626x10^{-34}}{94.85x10^{-12}} = -6.98x10^{-24}\,kgm/s$ (b)Kinetic energy of the electron after the photon is scattered The energy lost by the photon appears as kinetic energy of the electron. Energy of incident radiation, E=Pc, where P=h/ƛ as initial momentum of the photon and equals to 7.36x10^{-24}kgm/s E=7.36X10^{-24}x3x10^8=2.21x10^{-15}J Energy of the scattered photon'=P'c=6.99x10^{-24}x3x10^8=2.10x10^{-15}J	

	ΔEphoton=Kinetic energy of electron =$1.1x10^{-16}$J	
7.	(a) Non-fossil fuels are alternative sources of energy or renewable sources of energy that do not rely on burning up. They tend to generate power that can be utilized indefinitely /2mks (b)At least two examples of non-fossil fuels: Wind, water, Solar power, geothermal, … /2mk Electricity can be produced from renewable sources such as wind, hydropower, solar power, biomass, wind, and geothermal. To produce electricity, a turbine generator set converts mechanical energy to electrical energy. In the cases of wind power and hydropower, turbine blades are moved directly by flowing wind and water, respectively. Solar photovoltaic panels convert sunlight directly to electricity using semiconductors. /2mk (In the cases of natural gas, coal, nuclear fission, biomass, petroleum, geothermal and solar thermal, the heat that is produced is used to create steam, which moves the blades of the turbine)	
8.	No. A wave is not a solid object, but a chain of disturbance. As described by the principle of superposition, the waves move through each other. **(3marks)**	
9.	We say that light has wave properties since we see it act like a wave when it is diffracted or refracted or exhibits interference with other light. We say that light has particle properties since we see it act like a particle in the photoelectric effect and Compton scattering. **(4marks)**	
11.	(a)Wave nature of matter: . Dividing these equations and making Tplanet the//1mk , But All matter can exhibit wave-like behavior. /1mk . For example, a beam of electrons can be diffracted just like a beam of light or a water wave. The concept that matter behaves like a wave is also referred to de Broglie hypothesis. Matter can have the properties of the wave like: Reflection, Refraction, Interference, Diffraction and Polarization. /1mk (b) Data: m=0.15kg, v=13m/s, h=6.63 10^{-34}J.s **To be found**: λ=? **Solution**: $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(0.15)(13)} = 3.33 \times 10^{-34}\text{m}$ /**2mks**	
12	**a**.Resonance occurs when an object capable of oscillating, has a force applied to it with a frequency equal to its natural frequency of oscillation. **/1mark** **b**.When two progressive waves of same amplitude and wavelength	

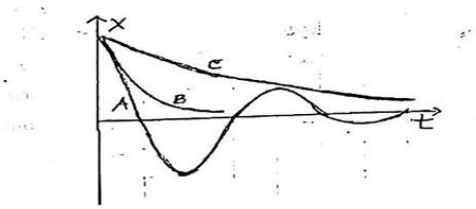
travelling along a straight line in opposite directions superimpose on each other, stationary waves are formed. **/1mark**

c.When a vibrating body is maintained in the state of vibration by a periodic force of frequency other than its natural frequency of the body, the vibrations are called forced vibrations. **/1mark**

d.Quantum mechanics is the system of laws which governs the behaviour of matter on the atomic scale. **/1mark**

e.An object that absorbs all radiation falling on it and therefore emitting radiation in whole spectrum of wavelengths is called a black body. **/1mark**

12.



(a) **The graph B (Critically damped oscillation) /1mk**

(b) **The frictional force (The resistive force)/1mk**

(c) **Data: m=2kg, F=3sin2πt, k=20N/m**

To be found: (a)T=? (b) A=?

Solution: (i) $\omega = \frac{2\pi}{T} = 2\pi$ **rad/s. So T=1s /1mk**

(ii) $\omega_0 = \sqrt{\frac{k}{m}} = \sqrt{\frac{20}{2}} = 3.16$**rad/s. The equation for the amplitude of adriven oscillator, with c=0, gives** $A = \frac{F_{max}}{m\sqrt{(\omega_0{}^2 - \omega_e{}^2)^2 + 4\delta^2\omega_e{}^2}} = \frac{F_{max}}{m(\omega_0{}^2 - \omega_e{}^2)} = \frac{3}{2(4\pi^2 - 3.16^2)} = 5.05$**cm /1mk**

14. a. Kepler's laws:

First Law: This law is called the law of orbits and states that planets move in ellipses with the sun as one of their foci. It can also be stated that planets describe ellipses about the sun as one focus. **/1mk**

Second Law: This is called the law of areas and states that the line joining the sun and the planet sweeps out equal areas in equal periods of time. **/1mk**

Third Law: The law of periods states that the square of the period T of revolution of any planet is proportional to the cube of its mean distance R from the sun. **/1mk**

The earth satellite is moving in uniform circular motion. The distance between the satellite orbit and the earth's surface d=640km. The satellite moves around earth's surface for a period T=98min. The radius of the satellite orbit is given by:

$R_{sat}=R_{earth}+d=6371000m+640000m=7011000m$

a.The period of the satellite is $v = \frac{2\pi \text{Rsat}}{T} = \frac{2\times\pi\times 7011000\text{m}}{60\times 98s} = 7491.1m/s$

b.The magnitude of centripetal acceleration is $a_c = \frac{v^2}{\text{Rsat}} = \frac{(7491.1m/s)^2}{7011000\text{m}} = 8.005m/s$

15 (a) **Kirchoff's Current Law (KCL) states that "The algebraic sum of the currents flowing at a node of junction in an electric circuit is zero" /1mk**
Kirchoff's Voltage Law (KVL) states that "The algebraic sum of the potentials around a closed electric circuit is zero."/1mk
(b) **Kirchoff's Voltage Law (KVL)** is a consequence of the principle of conservation of energy. **/1mk**

Using KVL: Considering the loop ahdcba,

$I_3(40+1)+30I_1=45$

$(I_1+I_2)(40+1)+30I_1=45$

$71I_1+41I_2=45$ **.....Equation (1)**

In the loop agfedcaba,

$I_3(40+1)+I_2(20+1)=80+45$

$(I_1+I_2)(40+1)+I_2(20+1)=80+45$

$71I_1+62I_2=125$ **.....Equation (2) /1mk**

Solving Equation (1) and Equation (2) simultaneously giv

$I_1=-0.87A$, $I_2=2.6A$ **and** $I_3=1.7A$. **/1mk**

SECTION B

16 **.a.**

Simple harmonic motion	**Damped oscillatory motion**
They are oscillatory motion	They are oscillatory motion
Free oscillation	System oscillates in presence of damping force
The constant amplitude over time	The amplitude diminishes with time
Total mechanical energy conserved	Total mechanical energy not conserved
Motion continues forever	Oscillating system will always come to rest

b.i. The amplitude A=0.080m,
ii.
$\omega = \frac{\pi}{2} rad$

iii.K=1.97N/m;
iv. the speed v=0m/s;
v.acceleration a=0.197m/s^2

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For an electron q=-e. $\vec{F} = q\vec{E}$ i.e are in opposite direction so $\vec{F}$ is upward. x-x_o=2.00cm and y-y_o=+0.5cm.

a.For the x component $v_{ox} = v_o = 1.6 \times 10^6 \frac{m}{s}$; $a_x = 0$ and $x - x_o = 0.02m$

$$x - x_o = v_{ox}t + \frac{1}{2}a_x t^2 \rightarrow x - x_o = v_{ox}t \rightarrow t = \frac{0.02}{1.6 \times 10^6} = 1.25 \times 10^{-8} s$$

For the y component $y_{oy} = 0$ and y-y_o=+0.0050m. what is $a_y = ?$

$y - y_o = v_{oy}t + \frac{1}{2}a_y \times t^2 \rightarrow y - y_o = \frac{1}{2}a_y t^2$ then

$a_y = 2\frac{y-y_o}{t^2} = 2\frac{0.0050m}{(1.25\times10^{-8}s)^2} = 6.40 \times 10^{13} \frac{m}{s^2}$)

and $qE = ma$ that gives $E = \frac{ma}{e} = \frac{(9.1\times10^{-31}kg)(6.40\times10^{13}\frac{m}{s^2})}{1.6\times10^{-19}c} = 364\,{}^{N}/_{C}$

b. $a = \frac{eE}{m_p} = \frac{(1.6\times10^{-19}c)(364\,{}^{N}/_{C})}{1.67\times^{-27}kg} = 3.487 \times 10^{10}\frac{m}{s}$ This is less than the acceleration of the electron in the part **(a)** so the vertical deflection is less and the proton will not hit the plates.

The proton has the same speed, so the proton takes the same time $t = 1.25 \times 10^{-8} s$ to travel horizontally the length of the plates.

$y - y_o = \frac{1}{2}(-3.487 \times 10^{10})(1.25 \times 10^{-8})^2 = -2.73 \times 10^{-6} m$

.

c.The paths are in opposite directions because the electron has a negative charge (i.e the electron will be deviated upward but the proton will be deviated downwards).
d.For both particles, the acceleration for each particle is much greater than that of gravity. So it is reasonable to ignore the effects of gravity for each particle.

18. (a) i) Thermionic emission i.e. the filament heats up the cathode
(Thermionic effect in this emission of electrons from surfaces of metals when they are heated)

ii) difference between cathode rays and x-rays

Cathode rays	X-rays
✓ Fast moving electrons ✓ Negatively charged ✓ Low penetrating power ✓ Deflected by electric and magnetic field ✓ Produce x-rays on string matter	✓ Electromagnetic wave ✓ Have no charge ✓ High penetrating power ✓ Cannot deflected by electric and magnetic field ✓ Eject electrons from matter

iii) C - Vertically deflect the beam
D - Horizontally defect the beam

(b) i) One wave $= 2ms/\,cm \times 2cm = 4ms = 4\times10^{-3}\,s = 0.004s$

ii) frequency= $f = \frac{1}{T} = \frac{1}{0.004\,S} = 250\,Hz$

(c) i) given $\Delta U = 4KV = 4\times10^{3}\,V, q = e = 1.6\times10^{19}\,C, m_e = 9.1\times10^{-31}\,Kg$

$W = \Delta U \times q = 4\times10^{3}\times1.6\times10^{-19} = 6.4\times10^{-16}\,J$

ii) $\frac{1}{2}m_e v^2 = eV \Rightarrow v = \sqrt{\frac{2eV}{m_e}}$

$v = \sqrt{\frac{2\times1.6\times10^{-19}\times4\times10^{3}}{9.1\times10^{-31}}} = \sqrt{1.4066\times10^{15}} = 3.75\times10^{7}\,m/s$

19. a.the equation y(x,t)=0.003cos(20x+200t) has the form y(x,t)=Acos(ωt+ϕ)
So it is travelling in the negative direction (to the left) **/2marks**

(b) (i)**Angular wave number or Propagation constant**, $k = \frac{\emptyset}{x} = \frac{20x}{x} = 20\text{m}^{-1}$. **/2mks**

(ii) **Angular frequency,** $\omega = 200$ **rad/s /2mks**

(iii)**Wave speed** $v = \lambda f = 0.31\times32 = 10\text{m/s}$ **/2mks**

(c) **Given** $x = 0.3m$ **and** $t = 0.02s$ $v = \frac{dy}{dt} = -0.003\times200\sin(20x+200t) = +0.33\text{m/s}$ **/3mks**

(d) **Given** $x = 0.3m$ **and** $t = 0.02s$ $a = \frac{dv}{dt} = -0.6\times200\cos(20x+200t) = +101\text{m/s}^2$ **/3mks**

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(a)

ADVANTAGES AND DISADVANTAGES OF FOSSIL FUELS

Introduction:

The world is moving towards green energy, but this does not mean that we can completely throw away fossil fuels. Fossil fuels are the most widely used energy sources in the world. **/1mk**

Disadvantages:

1. Fossil fuels are not renewable energy sources

If we do not reduce consumption, we will run out of them, very quickly. In this case, very quickly means maybe in our life span.

According to Woldometers, we will run out of oil in 47 years, natural gas in 52 years, and coal in 133 years. In the long term, if we want to use energy sources that will never run out, there are better alternatives than fossil fuels.

2. Fossil fuels pollute the environment

Fossil fuels contribute to greenhouse gases, which is one of their major disadvantages. The most harmful for the environment is coal because it has many more harmful combustion products than other fossil fuels.

In contrast, natural gas is the most environmentally friendly fossil fuel simply because it burns much cleaner. It means that if we burn natural gas under perfect combustion circumstances, there will be minimal to no harmful compounds.

But the bottom line is that fossil fuels are probably the main contributors to global warming, which is a major fossil fuel disadvantage because it is one of the biggest threats to humanity. That is why we do not hear good things about fossil fuels.

3. In the case of irresponsible use, they can be dangerous

It is important to note that fossil fuels are not the most dangerous energy sources. If we compare them to nuclear energy, we can easily see that nuclear power is much more dangerous.

But, in case of irresponsible use, they may cause an accident. For example, natural gas is a really flammable energy source, which is both an advantage and a disadvantage. Because of its inflammability, natural gas is the most commonly used energy source in the EU. But on the other hand, it is a combustible material which can explode. This is the biggest disadvantage of natural gas.

But oil is not safer either. In 2010, an ultra-deepwater drilling rig called Deepwater Horizon exploded, causing the largest marine oil spill in history. It shows that they can be dangerous not only to human life but to nature as well. But then why do we use them?

The critics of fossil fuels are much louder than the supporters. So, what are the advantages of fossil fuels?

Advantages:

1. Easier to store and transport

Fossil fuels can be transported quite easily. They are typically transported via international gas pipeline systems or with tankers.

Renewable energy sources cannot be stored efficiently. In contrast, fossil fuels can be stored for an indefinite period of time. It is beneficial because we can prepare for the times when we need them, such as winter.

2. It is really cheap

Since it has been used for centuries, we have a great and well-developed infrastructure for fossil fuels. It means that we can use them effectively, and they are relatively cheap.

If the circumstances are good, and the weather is mild, we can store the surplus, which means its price will fall. The price is also falling steadily due to the rise of renewable energy sources, which is not a drawback of using fossil

fuels

3. It is more reliable than renewable energy
One of the biggest disadvantages of renewable energy is that it depends on changes in the environment. If the wind blows or the sun shines, the solar panel's or wind turbine's operation is efficient. But if the conditions or the weather are not ideal, they use only half of their maximum capacity.
However, fossil fuel usage is completely under our control, and it does not depend on environmental factors. /**3mks**

Conclusion:
Petroleum, natural gas, and coal are the most widely used energy sources in the world. They account for ~80% of the total energy consumption.
There are a lot of well-known cons of fossil fuels, for example, their role in the greenhouse effect.
We do not often hear about the positives of fossil fuels. That is why it is worth considering the benefits of fossil fuels, too. We use them because they are cheap, effective, and reliable.
Like everything, all energy sources have their pros and cons. It is our job to find out what is the best both for the environment and for humanity. /**1mk**

(b) The Problems and Solutions of Fossil Fuels
Cars and trucks release nitrogen into the atmosphere, which contributes to nutrient pollution in our air and water.
Airborne nitrogen pollution affects not only the quality of the air we breathe, but also the land and the water. Nitrogen is the most abundant element in the air and is essential to plant and animal life. Sources of nitrogen from human activities, such as electric power generation, industry, transportation and agriculture, can upset the natural balance of nitrogen in the environment.
When fossil fuels are burned, they release nitrogen oxides into the atmosphere, which contribute to the formation of smog and acid rain. The most common nitrogen-related compounds emitted into the air by human activities are collectively referred to as nitrogen oxides. Ammonia is another nitrogen compound emitted to the air, primarily from agricultural activities, but also from fossil fuels. Most of the nitrogen oxides released in the U.S. due to human activity are from the burning of fossil fuels associated with transportation and industry.

When fossil fuels are burned, they release nitrogen oxides into the atmosphere, which contribute to the formation of smog and acid rain.
Major sources of nitrogen oxide emissions include:

Cars and trucks

Coal-fired power plants

Large industrial operations

Ships and airplanes

The presence of excess nitrogen in the atmosphere in the form of nitrogen

oxides or ammonia is deposited back onto land, where it washes into nearby water bodies. These excess nutrients contribute to pollution, harmful algal blooms and oxygen-deprived aquatic zones. Excess ammonia and low pH in these areas are toxic to aquatic organisms and affect their survival.

Solutions

Businesses:

There are many ways that businesses can reduce nutrient pollution, including:

Manage and Reduce Emissions Leading businesses are taking steps to understand and manage their greenhouse gas emissions by preparing annual greenhouse gas inventories and setting long-term targets to reduce emissions.

Increase Energy Efficiency Improving energy efficiency not only reduces greenhouse gas emissions into the atmosphere, it is good for a corporation's bottom line. Developing and implementing an effective corporate energy management program allows companies to manage energy with the same expertise used to manage other aspects of their business.

Buy Renewable Energy Your organization's purchased electricity use can be a significant source of air pollution and greenhouse gas emissions. Buying renewable energy, can help reduce your organization's environmental impact while also providing a number of other valuable benefits.

Individuals:

Conserve Energy Air pollution from energy production leads to acid rain, excess greenhouse gases, and health risks. One important step you can take to minimize airborne nutrient pollution is to conserve energy. You can do this by:

- Turning off lights, computers, televisions, video games and other electrical equipment when you're not using them.
- Buying equipment that uses less electricity, including lights, air conditioners, heaters, refrigerators and washing machines. Energy Star-certified products and buildings use at least 10 less energy than standard models.
- Limiting the use of air conditioning.
- Installing a programmable thermostat.

Minimize the Miles Driving cars and trucks also produces significant amounts of nitrogen oxide emissions. To help cut down on air pollution from cars, you can consolidate driving trips, carpool or take public transportation, such as buses and trains. When possible, consider walking or biking instead of driving. /**5mks**