$$\frac{90}{100} = \frac{10{,}000}{P_{Input}}$$

$$P_{Input} = 11{,}111.11 \text{ W } \checkmark$$

Power loss $= P_{Input} - P_{output}$

$$= 11{,}111.11 - 10{,}000$$

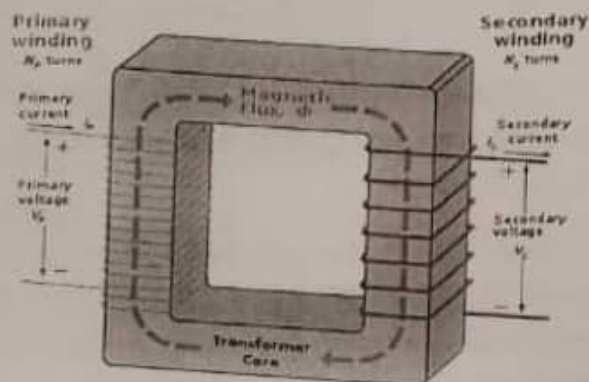Power loss $= 1{,}111 \text{ W } \checkmark$

03 points

Conclusion

So, the transformer will waste approximately 1.111 W during operation.

b) Identification

- A transformer changes the voltage of an alternating current through underlined electromagnetic induction.

Description of the design features

- The underlined primary coil has 2,000 turns and is connected to the high voltage (3.3 kV) supply. The alternating current in the primary coil generates a changing magnetic field.
- The underlined secondary coil has approximately 133 turns and is where the reduced voltage (220 V) is induced.
- The coils are wound around a underlined magnetic core, usually made of laminated iron. The core's purpose is to efficiently channel the magnetic field from the primary to the secondary coil.

Explanation of the Principle of operation

06 points

- When AC flows through the primary coil, it creates a changing magnetic field. This magnetic field induces a voltage in the secondary coil, proportional to the ratio of the number of turns in the two coils.

- The reduction in voltage is due to the <u>ratio of the number of turns in the primary to the secondary coil</u>. In this case, the primary has 15 times more turns than the secondary, so the voltage is reduced by a factor of 15 (from 3.3 kV to 220 V).

c) Identification of the process

Factory motors often require Direct Current (DC) rather than Alternating Current (AC). To convert AC from the mains to DC, a <u>rectifier</u> is used.

Explanation of the process

- When a rectifier is connected to a supply it's supposed to <u>conduct and when it does so it's said to be forward biased</u>.
- And when connected in a <u>reverse way it fails to conduct</u> therefore it said to be reverse-biased.
- Current to be measure is fed to the meter through the rectifier diode which <u>conducts current in only one direction</u>.
- So, a direct current of <u>varying magnitude flows through the circuit</u> in the same direction throughout which can be used to run the DC motor.

04 points

=16 points

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6 | a) Explanation

- A pressure cooker <u>is a sealed pot with a locking lid that traps steam</u>. When the pot is heated, the water inside boils and turns to steam.
- In a normal cooking environment, <u>the boiling point of water is 100 °C at sea level</u>, where the atmospheric pressure is 101.3 kPa.
- As the water boils in the pressure cooker, <u>the steam can't escape</u>, causing the pressure inside the cooker to increase.
- This <u>increased pressure raises the boiling point</u> of water above 100 °C. For example, at 199 kPa, water boils at approximately 120 °C.
- <u>The higher temperature allows food to cook faster</u> and more thoroughly, especially at high altitudes where atmospheric pressure is lower.
- The pressure cooker is equipped with a pressure <u>regulator valve that maintains</u> a set internal pressure. If the pressure

06 points

exceeds the safety limit, the valve releases some steam to prevent an explosion.

b) Using the formula:
$$Pressure\ change = phg$$
$$= 1.25 \times 5600 \times 10$$
$$= 70\ kPa \checkmark$$

So, the atmospheric pressure at 5,600 m

Atmospheric pressure at 5600m = 101.3 − 70

$$= 31.3\ kPa \checkmark$$

$$Required\ pressure = 199 − 31.3$$
$$= 167.7\ kPa \checkmark$$

05 points

Conclusion

The pressure cooker's regulator must be adjusted to maintain an internal pressure that is 167.7 kPa above the external pressure.

c) Explanation
- Cooking at high altitude poses challenges because of the lower atmospheric pressure, which reduces the boiling point of water.
- At higher altitudes, the atmospheric pressure is lower, so water boils at a lower temperature. This means that food cooked in boiling water at high altitude will cook more slowly because the temperature is not as high as it would be at sea level.

05 points

- To compensate for the reduced boiling point, food must be cooked at a higher temperature.
- The increased temperature in a pressure cooker ensures that food reaches the proper temperature needed to break down fibers and kill harmful bacteria.

=16 scores

- Traditional incandescent bulbs are less efficient than LEDs. They require more power to produce the same amount of light. This inefficiency could be another reason why the light seemed dim.

c) Identification of principle
- It uses principle of Electromagnetic Induction to convert mechanical energy into electrical energy

Explanation
- The dynamo is equipped with a magnet and a coil of wire. As you pedal, the rotation of the bicycle wheel turns the magnet inside the dynamo. This motion creates a changing magnetic field around the coil of wire.
- According to Faraday's Law of Electromagnetic Induction, a changing magnetic field induces an electromotive force. This voltage is what powers the electrical circuit, including your light.
- The voltage generated by the dynamo is alternating current because the magnet's poles are constantly changing their orientation relative to the coil as it rotates.
- The amount of power generated depends on the speed of rotation and the load the resistance in the circuit, and the bulb.

06 points

= 16 Scores

5 | 5 a) (i) Use of formula:
$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{3300}{220} = \frac{N_s}{2000}$$
$$N_s = 133.33 \text{ turns}$$

03 points

Conclusion
Should use a step-down transformer with 2000 turns in the primary coil and 133 turns in the secondary coil that will reduce the voltage from 3.3kV to 220 V

(ii) Use of formula:
$$Efficiency = \frac{P_{output}}{P_{input}}$$

- It inspires students and the public about space science through _educational outreach_, live broadcasts, and interactions with astronauts

Any 3 points

04 points

- Helps in monitoring _environmental changes_, natural disasters, and climate phenomena on Earth, and conducts astronomical observations.

- Helps in studying the effects of long-term spaceflight on the human body, aiding in the _health and safety of astronauts_ on future deep-space missions.

= 16 Scores

4   4 a) Use of formula:

$$Efficiency = \frac{P_{output}}{P_{input}}$$

$$0.8 = \frac{P_{output}}{3} \checkmark$$

$$Power_{output} = 2.4 \ W \checkmark$$

$$P_{output} = \frac{V^2}{R}$$

$$2.4 = \frac{V^2}{5} \checkmark$$

$$V = 3.46 \ V \checkmark$$

Conclusion

Given that the LED bulb requires a minimum of 3.6 V, the 3.46 V generated by the dynamo should be sufficient for the LED bulb to operate efficiently.

b) Explanation

- The voltage generated by a dynamo is proportional to the _rotational speed of the bicycle's wheel_. If you were pedaling slowly, the dynamo would generate less voltage, leading to a dimmer light.

05 points

- As noted, the dynamo is 80% _efficient_, meaning 20% of the energy is lost, likely due to friction or heat. This loss reduces the amount of usable power for the light, potentially making it dim.

05 points

- High _resistance_ in the wiring or connections can also reduce the voltage reaching the bulb. If there were any corroded or loose connections, they could increase resistance and decrease the brightness of the light.

b) Identification and description

Due to the phases of the moon which occur as a result of the moon's orbit around the Earth and the way sunlight illuminates it.

- _New Moon_ appears when the moon is between the Earth and the Sun, the side facing Earth is in shadow, so we can't see it.

- _Waxing Crescent_ appears as the moon moves in its orbit, a small sliver of the sunlit side becomes visible.

- The _First Quarter_ appears when half of the moon's surface facing Earth is illuminated. All moon phases identified and described

- _Waxing Gibbous_ is when more than half of the moon is visible as it continues to orbit.

- _Full Moon_ is seen when the entire face of the moon that faces Earth is fully illuminated by the Sun.

- _Waning Gibbous_ is seen when the moon starts to wane, and less of the illuminated surface is visible.

- The _Last Quarter_ is seen again, when half of the moon's surface facing Earth is visible, but the opposite side compared to the First Quarter.

- The _waning Crescent_ occurs when only a small crescent is visible before it returns to the New Moon phase. This cycle takes about 29.5 days to complete.

06 points

b) Explanation

- Space exploration enables _scientific_ research in fields like biology, physics, and materials science, enabling studies not possible on Earth.

- It promotes _international cooperation_ and peaceful use of space for example use of ISS.

- Radioactive contamination can affect plants, animals, and microorganisms. It can lead to mutations, reduce biodiversity, and disrupt ecosystems. For example, contaminated plants might be eaten by animals, passing the radiation up the food chain.   Any 2 points   **02 points**
- The effects of radiation on the environment are long-lasting. It can make large areas uninhabitable, as seen in places like Chernobyl. The cleanup and containment of radioactive materials are also challenging and expensive.   = 16 Scores

3 a) Identification

- Ocean tides are caused by the gravitational interactions between the Moon, Earth, and Sun. ✓

Explanation

- The Moon, being closest to Earth, exerts a significant gravitational pull on our planet. This pull is strongest on the side of the Earth facing the Moon, causing the water to bulge outwards, creating high tide. ✓
- The Moon's gravity pulls the water in the oceans causing it to bulge out toward the Moon. This creates a high tide on the side of the Earth facing the Moon.   **06 points**
- On the opposite side of the Earth, another high tide occurs as the Earth is pulled slightly toward the Moon, leaving water behind, which also bulges out due to inertia.
- The Sun also exerts a gravitational pull on the Earth, contributing to the tides though its effect is less than that of the Moon.
- When the Sun, Moon, and Earth are aligned (during full and new moons), the combined gravitational forces create higher high tides and lower low tides, known as spring tides.
- When the Sun and Moon are at right angles relative to the Earth (during the first and third quarters of the moon), the gravitational forces partially cancel each other out, resulting in lower high tides and higher low tides, known as neap tides.

- In fission, the nucleus of <u>a heavy atom splits into smaller</u> | 03 points
  <u>nuclei</u>, releasing a large amount of energy, along with neutrons
  and radiation. This energy is harnessed to produce
  electricity.

Consequences/Dangers
- During nuclear accident, the control over the fission reaction
  may be lost, leading to an uncontrolled chain reaction. This
  can cause the reactor to overheat and potentially lead to the
  <u>release of radioactive materials</u> into the environment.
- People in the vicinity can be exposed to harmful radiation,
  which can damage cells and tissues, leading to acute radiation
  sickness, cancer, or other <u>health issues</u>. Any 2 points
- Radioactive materials can contaminate air, water, and soil, | 02 points
  leading to long-term <u>environmental and health hazards.</u>

(ii) Precautions
- **Patients** undergoing X-ray examinations are often provided
  with <u>lead aprons or shields</u> to protect parts of their bodies
  not being imaged, reducing unnecessary exposure to X-rays.
- X-ray machines are calibrated to use the <u>lowest possible dose
  of radiation</u> while still obtaining a clear image to reduce time
  of exposure.
- **Staff** <u>use protective clothing</u>, including lead aprons, thyroid
  shields, and leaded glasses, to reduce their exposure to X-
  rays.
  Any 2 points | 02 points
- Keeping a <u>safe distance</u> from the X-ray source and using
  physical barriers (like lead walls) helps protect medical
  personnel from radiation.
- Health workers often <u>wear dosimeters</u> to monitor their
  exposure to radiation over time, ensuring it stays within safe
  limits.

c) Environmental Implication
- When radioactive materials are released into the
  environment, <u>they can contaminate air, water, and soil</u>. This
  contamination can persist for years or even decades,
  depending on the half-life of the radioactive substances.

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However, because space lacks an atmosphere to scatter ✓ **04 points**
light, it appears dark.
- On Earth, the atmosphere contains gases and particles that ✓
  scatter sunlight in all directions. Blue light has a shorter
  wavelength and is scattered more than other colors. This ✓
  scattering causes the sky to appear blue during the day.

c) (i) Comparison of properties
- Light waves do not require a medium and can travel through
  a vacuum whereas sound waves require a medium to travel.
- Light waves are electromagnetic waves (transverse waves)
  whereas sound waves are mechanical waves (longitudinal   **04 points**
  waves). ✓
- Light waves travel at the speed of $3.0 \times 10^8 \ ms^{-1}$ in a vacuum
  whereas sound waves travel much slower at a speed of
  $320 \ ms^{-1}$.
- Visible light has a short wavelength of about $500 \ nm$ and high
  frequency of about $6 \times 10^{14} \ Hz$ whereas a sound frequency
  of $200 \ Hz$, the wavelength in air is about $1.7 \ m$.

(ii) Use of formula;
> For light;
>> $V = f\lambda$
>> $V = 6 \times 10^{14} \times 500 \times 10^{-9}$
>> $= 3.0 \times 10^8 \ ms^{-1}$ ✓

> For sound;
>> $V = f\lambda$ ✓
>> $V = 200 \times 1.7$
>> $= 340 \ ms^{-1}$ ✓

04 points

Conclusion
The speed of light is much faster than the speed of sound. This
difference in speeds is why the astronauts observed the flash of
lightning before hearing the thunder. ✓

=16pts

2 a) (i) Explanation
- X-rays are used in medicine to create images of the inside of ✓
  the body. These images help doctors see bones, organs, and
  tissues, which are not visible from the outside.

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- X-rays are particularly useful for detecting fractures, infections, tumors, and other internal conditions. When X-rays pass through the body, they are absorbed differently by different types of tissues. Any 3 points clearly explained
- Bones, which are dense, absorb more X-rays and appear white on the X-ray image. Softer tissues like muscles and organs absorb fewer X-rays and appear in shades of gray.

03 points

- Any areas that absorb very few or no X-rays, such as air spaces, appear black. This contrast helps doctors identify abnormalities inside the body.

(ii)   Identification of a process
- X-rays are produced by means of thermionic emission
  Description of the process
- In an X-ray machine, electrons are emitted from a heated (filament) cathode and accelerated towards a metal target (anode) using a high voltage.   Any four clearly explained points
- The cathode is heated by a low voltage and electrons are emitted from it by thermionic emission.

04 points

- The electrons are accelerated to the anode by the high voltage supply connected across the cathode and anode.
- When these fast-moving electrons collide with the metal target, their kinetic energy is converted into X-rays and heat energy. The 99% of the kinetic energy of electrons is converted into heat and 1% of kinetic energy of elections is converted into X-rays.
- The heat generated at the target is cooled down by means of cooling fins and then conducted.
- The X - ray tube is evacuated to prevent cathode rays from colliding with air molecules hence allowing free movement of electrons in the tube.

b) (i) **Identification and explanation**
- Nuclear power plants use a process called nuclear fission to generate energy.
- This process is started by bombardment of a heavy nucleus with a slow-moving neutron.

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4

PHYSICS

Paper 1

Theory

Scoring guide

1	a) Explanation of the reasons	
	• Sound requires a medium like air, water, or solid material to travel because it is a mechanical wave. On Earth, sound travels through the air, allowing us to hear each other. However, the Moon has no atmosphere, meaning there is no air or other medium for the sound waves to propagate through. This is why the astronauts couldn't hear each other even though they were shouting.	04 points
	• The telephone system designed for lunar communication converts sound waves into electrical signals that can be transmitted through wires or radio waves. These electrical signals don't require material medium to travel; they can be transmitted through a vacuum. When the telephone system converts the electrical signals back into sound waves within the receiver, the astronauts could hear each other. This is why the telephone allowed successful communication on the Moon.	
	b) Explanation of a reason	
	• Light is an electromagnetic wave, it doesn't require a medium to travel. It can move through the vacuum of space, which is why astronauts can see the sun and other stars.	