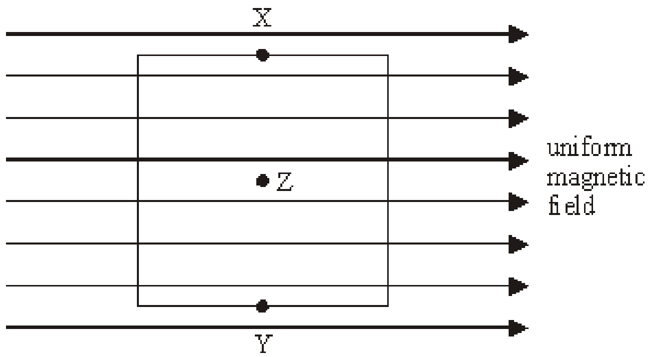
Q1.



The diagram shows a square coil with its plane parallel to a uniform magnetic field. Which one of the following would induce an emf in the coil?

A movement of the coil slightly to the left

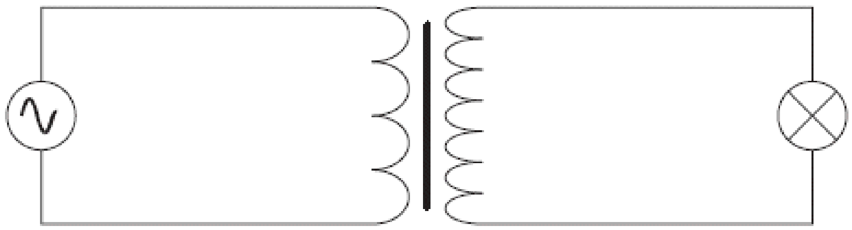
B movement of the coil slightly downwards

C rotation of the coil about an axis through XY

D rotation of the coil about an axis perpendicular to the plane of the coil through Z

(Total 1 mark)

Q2. The primary coil of a step-up transformer is connected to a source of alternating pd. The secondary coil is connected to a lamp.



Which line, **A** to **D**, in the table correctly describes the flux linkage and current through the secondary coil in relation to the primary coil?

	$\frac{\text{secondary magnetic flux linkage}}{\text{primary magnetic flux linkage}}$	$\frac{\text{secondary current}}{\text{primary current}}$
A	>1	<1
B	<1	<1
C	>1	>1
D	<1	>1

(Total 1 mark)

Q3. A transformer has 1200 turns on the primary coil and 500 turns on the secondary coil. The primary coil draws a current of 0.25 A from a 240 V ac supply. If the efficiency of the transformer is 83%, what is the current in the secondary coil?

A 0.10 A

B 0.21 A

C 0.50 A

D 0.60 A

Q4. Why, when transporting electricity on the National Grid, are high voltages and low currents used?

A The energy lost by radiation from electromagnetic waves is reduced.

B The electrons move more rapidly.

C The heat losses are reduced.

D The resistance of the power lines is reduced.

(Total 1 mark)

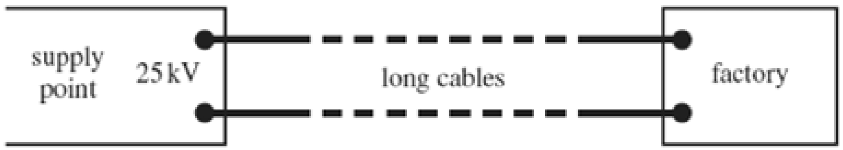
Q5. The primary winding of a perfectly efficient transformer has 200 turns and the secondary has 1000 turns. When a sinusoidal pd of rms value 10 V is applied to the input, there is a primary current of rms value 0.10 A rms. Which line in the following table, **A** to **D**, gives correct rms output values obtainable from the secondary when the primary is supplied in this way?

	rms output emf/V	**rms output current/A**
A	50	0.10
B	50	0.02
C	10	0.10
D	10	0.02

(Total 1 mark)

Q6. (a) Long cables are used to send electrical power from a supply point to a factory some distance away, as shown in **Figure 1**. An input power of 500 kW at 25 kV is supplied to the cables.

Figure 1



(i) Calculate the current in the cables.

answer = ...A

(1)

(ii) The total resistance of the cables is 30Ω. Calculate the power supplied to the factory by the cables.

answer = ...kW

(2)

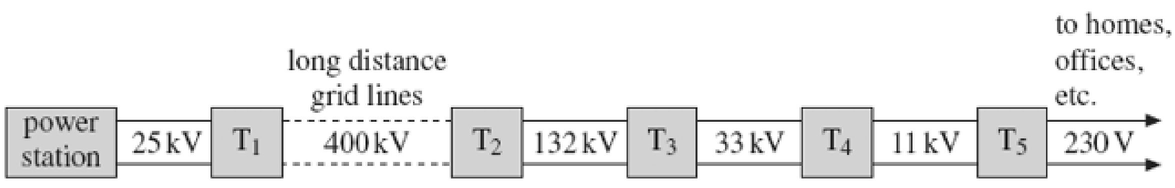
(iii) Calculate the efficiency with which power is transmitted by the cables from the input at the supply point to the factory.

answer = ...%

(1)

(b) In Great Britain, the electrical generators at power stations provide an output at 25 kV. Most homes, offices and shops are supplied with electricity at 230 V. Power is transmitted from the power stations to the consumers by the grid system, the main principles of which are shown in **Figure 2**. In this network, T_1, T_2, T_3, etc, are transformers.

Figure 2



(i) Explain how a step-down transformer differs in construction from a step-up transformer.

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....

....

(1)

(ii) Explain why the secondary windings of a step-down transformer should be made from thicker copper wire than the primary windings.

....

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....

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(2)

(c) Discuss the principles involved in high voltage transmission systems, explaining why a.c. is used in preference to d.c. and how the energy losses are minimised.

The quality of your written communication will be assessed in this question.

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(6)
(Total 13 marks)

Q7. (a) (i) Outline the essential features of a step-down transformer when in operation.

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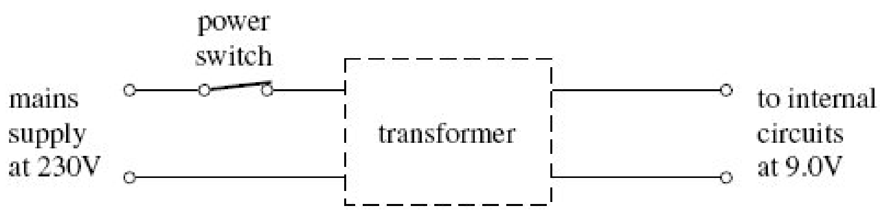
(2)

(ii) Describe **two** causes of the energy losses in a transformer and discuss how these energy losses may be reduced by suitable design and choice of materials.
The quality of your written communication will be assessed in this question.

(Allow one lined page).

(6)

(b) Electronic equipment, such as a TV set, may usually be left in 'standby' mode so that it is available for instant use when needed. Equipment left in standby mode continues to consume a small amount of power. The internal circuits operate at low voltage, supplied from a transformer. The transformer is disconnected from the mains supply only when the power switch on the equipment is turned off. This arrangement is outlined in the diagram below.



When in standby mode, the transformer supplies an output current of 300 mA at 9.0V to the internal circuits of the TV set.

(i) Calculate the power wasted in the internal circuits when the TV set is left in standby mode.

answer = ... W

(1)

(ii) If the efficiency of the transformer is 0.90, show that the current supplied by the 230 V mains supply under these conditions is 13 mA.

(2)

(iii) The TV set is left in standby mode for 80% of the time. Calculate the amount of energy, in J, that is wasted in one year through the use of the standby mode.

1 year = 3.15×10^7 s

answer = ... J

(1)

(iv) Show that the cost of this wasted energy will be about £4, if electrical energy is charged at 20 p per kWh.

(2)

(c) The power consumption of an inactive desktop computer is typically double that of a TV set in standby mode. This waste of energy may be avoided by switching off the computer every time it is not in use. Discuss **one** advantage and **one** disadvantage of doing this.

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(2)
(Total 16 marks)

M1. C

[1]

M2. A

[1]

M3. C

[1]

M4. C

[1]

M5. B

[1]

M6. (a) (i) current $I \left(= \frac{P}{V}\right) = \frac{500 \times 10^3}{25 \times 10^3}$ = 20 (A) ✓ 11

(ii) wasted power ($I^2 R$) = $20^2 \times 30 = 1.20 \times 10^4$ (W) (12.0 kW) ✓

power output from cables = 500 – 12 = 488 (kW) ✓

or voltage drop along cables = IR = 20 × 30 = 600 (V)

∴ output voltage = 25000 – 600 = 24400 (V) ✓

power output = IV = 20 × 24400 = 4.88×10^5 (W) ✓

(iii) efficiency $\left(= \frac{P_{out}}{P_{in}}\right) = \frac{488}{500} \times 100$ = 98 (97.6) (%) ✓ 1

(b) (i) primary coil must have more turns than secondary ✓

1

(ii) to reduce heating (I^2R) loss [**or** energy/power/copper loss] ✓

(because) $I_S > I_P$ ✓

and R is reduced (by use of thicker wire) ✓

max 2

(c) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate provides a comprehensive and logical description of the main principles of the grid system. They should identify I^2R heating as the main cause of energy loss, and know that this can be reduced by using transformers to raise voltage and therefore decrease current (for the same power), and that transformers require ac. They may not have referred to safety and insulation issues that ultimately require the voltage to be reduced again or to energy losses from transformers.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate provides a description of the main features of the grid system which recognises that heating losses can be reduced by use of transformers to decrease the current. They should know that transformers require ac. They may not fully explain the reasoning for the use of a higher voltage and they are unlikely to refer to safety and insulation issues that require the voltage to be reduced again.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

The candidate recognises that the use of higher voltage will reduce transmission losses and that transformers need ac. They give a much weaker account (if any) of the underlying principles.

Incorrect, inappropriate of no response: 0 marks

No answer or answer refers to unrelated, incorrect or inappropriate physics.

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.

voltages are changed using transformers, which work with ac but not with dc

ac generation and transmission is therefore essential

current in cables causes joule heating (or I^2R loss)

resistance of cables should be as low as possible

losses are reduced if current in cables can be reduced

current can be reduced (for same power $I\ V$) if voltage is increased

the higher the voltage, the smaller the proportion of the input power that is wasted

high voltage introduces insulation problems and raises safety issues

voltage must be reduced as the supply reaches its consumers

this is done in stages as the supply is moved from overhead cables to underground wires

transformers cause energy losses because they are not perfectly efficient

features are incorporated in the design of transformers to reduce losses from them

max 6

[13]

M7. (a) (i) primary coil with more turns than secondary coil **(1)**

(wound around) a core **or** input is ac **(1)**

2

(ii) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	Two causes of energy losses are clearly identified, correct measures to indicate how these two losses may be reduced are stated and a detailed physical explanation of why these measures are effective is given. eg **any two** from the following four 1 When a transformer is in operation, there are ac currents in the primary and secondary coils. The coils have some resistance and the currents cause **heating of the coils**, causing some energy to be lost. This loss may be reduced by using **low resistance wire** for the coils. This is most important for the high current winding (the secondary coil of a step-down transformer). Thick copper wire is used for this winding, because thick wire of low resistivity has a low resistance. 2 The ac current in the primary coil magnetises, demagnetises and re-magnetises the core continuously in opposite directions. Energy is required both to **magnetise and to demagnetise the core** and this energy is wasted because it simply heats the core. The energy wasted may be reduced by choosing a material for the core which is easily magnetised and demagnetised, ie a **magnetically soft material** such as iron, or a special alloy, rather than steel. 3 The magnetic flux passing through the core is changing continuously. The metallic core is being cut by this flux and the continuous change of flux induces emfs in the core. In a continuous core these induced emfs cause currents known as **eddy currents**, which heat the core and cause energy to be wasted. The eddy current effect may be reduced by laminating the core instead of having a continuous solid core; the laminations are separated by very thin layers of insulator. Currents cannot flow in a conductor which is discontinuous (or which has a very high resistance). 4 If a transformer is to be efficient, as much as possible of the magnetic flux created by the primary current must pass through the secondary coil. This will not happen if these coils are widely separated from each other on the core. **Magnetic losses** may be reduced by adopting a design which has the two coils close together, eg by **better core design**, such as winding them on top of each other around the same part of a common core which also surrounds them.	**5-6**

modest-adequate	Up to two sources of energy losses are stated and there is an indication of how these may be minimised by suitable features or materials. There is no clear appreciation of an understanding of the physical principles to explain why these measures are effective.	**3-4**
poor-limited	Up to two sources of energy losses are given, but the answer shows no clear understanding of the measures required to minimise them.	**1-2**
incorrect, inappropriate or no response	There is no answer or the answer presented is irrelevant or incorrect.	**0**

Answers which address only **one** acceptable energy loss should be marked using the same principles, but to max 3.

6

(b) (i) power wasted internally (= $I V$) = 0.30 × 9.0 = 2.7 (W) **(1)**

1

(ii) input power $\left(= \frac{2.7}{0.90}\right)$ = 3.0 (W) **(1)**

mains current $\left(= \frac{3.0}{230}\right)$ **(1)** (= 1.30×10^{-2} A)

2

(iii) energy wasted per year (= $P t$) = 3.0 × 0.80 × 3.15×10^{7}
= $7.5(6) \times 10^{7}$ (J) **(1)**

1

(iv) energy wasted = $\frac{7.56 \times 10^{7}}{3.6 \times 10^{6}}$ = 21.0 (kWh) **(1)**

cost of wasted energy = 21.0 × 20 = 420p (£4.20) **(1)**

2

(c) answers should refer to:

an advantage of switching off **(1)**

- cost saving, saving essential fuel resources, reduced global warming etc

a disadvantage of switching off **(1)**

- inconvenience of waiting, time taken for computer to reboot etc
- risk of computer failure increased by repeated switching on and off
- energy required to reboot may exceed energy saved by switching off

2

[16]