Electricity Test

Answers to questions to be written in the space provided

Answers to questions involving calculations should be evaluated and given in decimal form.
Quote the final answer to not more than four significant figures.

Marks maybe deducted for not showing working.
Working must be legible and clearly set out.

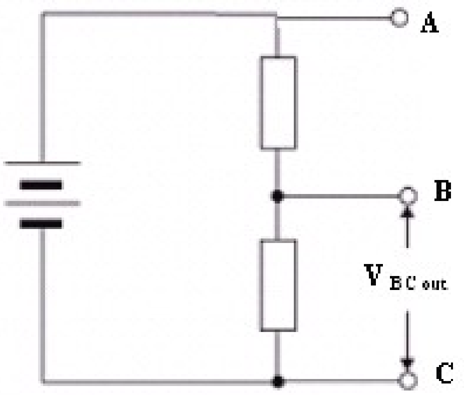
Questions containing the instruction estimate may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained.

SOLUTIONS

Mark__________/45

Short Answers
(4marks per question)

1. A two resistor voltage divider is often used to supply a voltage that is different from the power supply. In application, the output voltage depends upon the resistance of the load it drives. The picture at right below shows a typical voltage divider, with connections made across different pin combinations resulting in different potential differences. The diagram below at left shows a simplified circuit diagram of the voltage divider



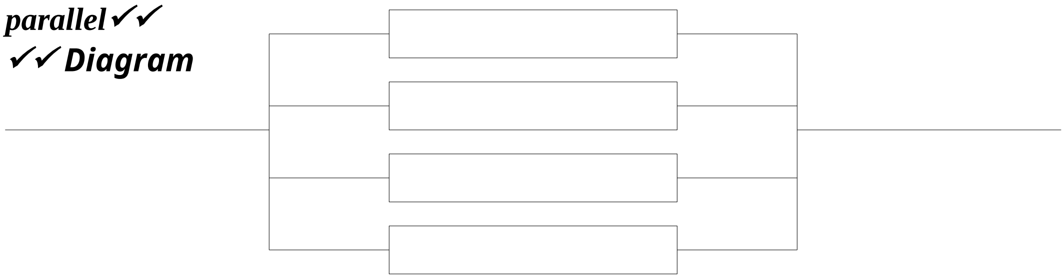
For this circuit , V_{IN}= 30.0 V, R_1= 5.0 kΩ and the output voltage $V_{BC\ OUT}$= 6.0 V

Calculate the value of the resistance R_2 in the circuit above?

V_2= 24.0V ✓
By proportion 6.0V ⇨ 5.0 kΩ, thus 24.0V ⇨ 20.0 kΩ✓✓✓
OR
V_2= 24.0V ✓
$V_1 = I_1R_1$
⇨ $6.0 = 5000 \times I_1$
⇨ $I_1 = 1.2 \times 10^{-3}$ A✓
Now $V_2 = I_2 R_2$
⇨ $24.0 = 1.2 \times 10^{-3} \times R_2$
⇨ R_2 = 20.0 kΩ✓✓

2. Suppose in the laboratory you wanted to construct a circuit with 5 kΩ resistance, but only have 20 kΩ resistors to work with. Explain how you could use 20kΩ resistors to create the equivalent resistance as a 5 kΩ resistor. Include a sketch to show the connections between the appropriate number of 20 kΩ resistors.

The R1 resistor needs to be constructed with four 20 kΩ resistors connected in parallel✓✓
✓✓ Diagram



3. Sketch the electric field that exists around a single isolated positive charge and use this diagram to explain what an electric field actually is?

The electric field is a zone of influence around the positive charge in which another small positive will experience a force of repulsion. ✓✓

Diagram ✓✓ ***REFER Ch11.2***

4. A balloon has been rubbed with wool to give it a charge of -1.0×10^{-6} C. A plastic rod with a charge of $+4.0 \times 10^{-6}$ C localized at a given position is held a distance of 50.0 cm above the balloon.

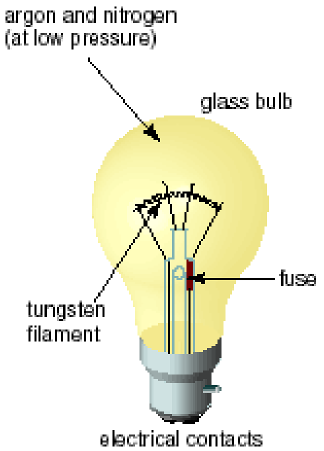
a. Estimate how many excess electrons are possessed by the balloon. **[2marks]**

1C = 6.242×10^{18}electrons ✓
$6.242\times10^{18} \times 1.0\times10^{-6}$
= 6.242×10^{12} ✓✓

b. Determine the electrical force of attraction between the rod and the balloon. **[2marks]**

$F = kq_1q_2/d^2$✓
$F = 9 \times10^{9} \times 1.0\times10^{-6} \times 4.0\times10^{-6} /(0.5)^2$
F = 0.14N✓✓

5. Sam repairs the cord on an electric kettle, but he mistakenly swapped the active and the neutral around. Is the kettle still capable of heating water and is it safe.



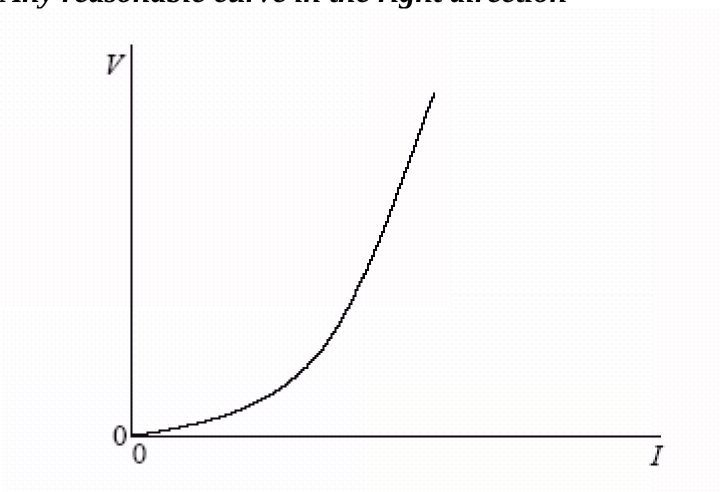
Yes✓***the kettle will still heat the water. This arrangement however is not safe***✓***as the wall switch is on the active line and even when it is turned off*** ✓***there is the possibility electrocution should an internal wire come loose.*** ✓

Long answer

1. In an incandescent bulb, the filament is made of a thin piece of tungsten metal, coiled to fit inside the bulb. When a current passes through the filament, it heats up and gives off visible light.

a. On the axes below, draw a sketch-graph to show how the current (I) in the filament lamp varies with potential difference (V) as the switch is turned on and the voltage increases to a maximum. *(**Note**: this is a sketch-graph;you do not need to add any values to the axes).* **[2marks]**

***Any reasonable curve in the right direction*✓✓**



b. Explain how the resistance of the filament is determined from the graph.

From the gradient of the graph at that particular point or from the value of V/I at any point on the curve . (Don't accept just V/I)✓✓ **[2marks]**

c. Explain whether the graph you have sketched indicates ohmic behaviour **or** non-ohmicbehaviour.

[2marks]

non-ohmic✓ because the resistance (V/I at each point) is not constant✓

A filament lamp operates at maximum brightness when connected to a 6.0 V supply. At maximumbrightness, the current in the filament is 120 mA.

d. Calculate the resistance of the filament when it is operating at maximum brightness.

[2marks]

V =I R
- ⇨ **6.0 = 0.12 x R**
- ⇨ **R = 6.0/0.12**
- ⇨ **R = 50.0Ω✓✓**

e. If the wire that makes up the filament has a diameter of 1.6 x 10^{-5} m, calculate the length of the tungsten in the globe.

[4marks]

A= πr^2
- ⇨ ***A = $\pi(1.6 \times 10^{-5}/2)^2$***
- ⇨ ***A = 2.01×10^{-10} m^2✓***

R = $\rho l/A$✓
- ⇨ ***50 = $(5.5 \times 10^{-8} \times l)/ 2.01 \times 10^{-10}$***
- ⇨ ***l = 1.83×10^{-1} m✓✓***

f. Suppose the tungsten wire was replaced by an identically sized copper wire. What would you observe when the light was switched on.

[3marks]

Since the resistivity of copper is less than that of tungsten, the resistance of the wire would be less and thus the current greater. ✓Since P = VI, the globe will glower brighter,✓ be hotter and could possibly burn out.✓

Comprehension
(10marks)

Read the following passages and answer the questions at the end of each. Candidates are reminded of the need for clear and concise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included as appropriate.

Walk into almost any business office, and you'll probably find a photocopier ("copier") with a line of people waiting to use it. For most businesses, small or large, the copier has become standard equipment, much like having a desk to work at and a chair to sit in.

What happens inside the copier at this point is amazing! At its heart, a copier works because of one basic physical principle: **opposite charges attract**. As a kid, you probably played with static electricity and balloons. **On a dry winter day**, you can rub a balloon on your sweater and create enough static electricity in the balloon to create a noticeable force. For example, a balloon charged with static electricity will attract small bits of paper or particles of sugar very easily.

A copier uses a similar process.

- Inside a copier there is a special **drum**. The drum acts a lot like a balloon – you can charge it with a form of static electricity.
- Inside the copier there is also a very fine black powder known as **toner**. The drum, charged with static electricity, can attract the neutral toner particles.

There are three things about the drum and the toner that let a copier perform its magic:

- The drum can be **selectively** charged, so that only parts of it attract toner. In a copier, you make an "image" – in static electricity – on the surface of the drum. Where the original sheet of paper is black, you create static electricity on the drum. Where it is white you do not. What you want is for the white areas of the original sheet of paper to **NOT** attract toner. The way this selectivity is accomplished in a copier is with light – this is why it's called a **photocopier**!
- Somehow the toner has to get onto the drum and then onto a sheet of paper. The drum selectively attracts toner. Then the sheet of paper gets charged with static electricity and it pulls the toner off the drum.
- The toner is **heat sensitive**, so the loose toner particles are attached (fused) to the paper with heat as soon as they come off the drum.

The **drum**, or belt, is made out of **photoconductive** material. Here are the actual steps involved in making a photocopy:

- The surface of the drum is charged to a charge of about +0.25 nC.
- An intense beam of light moves across the paper that you have placed on the copier's glass surface. Light is reflected from white areas of the paper and strikes the drum below.

- Wherever a photon of light hits, electrons are emitted from the photoconductive atoms in the drum and neutralize the positive charges above. Dark areas on the original (such as pictures or text) do not reflect light onto the drum, leaving regions of positive charges on the drum's surface.
- Black pigment called **toner** is then spread over the surface of the drum, and the pigment particles adhere to the positive charges that remain.
- A sheet of paper positively charged to about 0.1 nC then passes over the surface of the drum at a distance of 1.0 mm, attracting the beads of toner away from it.
- The paper is then heated and pressed to fuse the image formed by the toner to the paper's surface.

a) What is meant by the term "**opposite charges attract**" ?

[1 marks]

This means that a positive and negative charge✓will experience a force that will try and move them closer to each other.✓

b) Why is a "**dry winter day"** necessary to demonstrate static electricity?

[1marks]

The air must be dry otherwise water molecules in the air will neutralise✓the charge quickly as they are attracted to any charged surface.✓

c) Explain how toner can be attracted to the drum when the toner is neutral.

[2 marks]

Many particles are made up of molecules which have one end slightly positive and the other slightly negative✓. The separation of charge✓means that the opposite end will always experience a force of attraction ✓grater than the same charge as it will be closer or rotate to be closer.

d) Explain what is meant by saying that a photocopier drum is selectively charged.

[1 marks]

Only parts of the drum remain charged✓. This is where the reflected light

has not hit ✓

e) How many electrons need to be removed from the drum in order to produce a charge of 0.25 nC?

[2 marks]

Charge on an electron is $\boldsymbol{-1.6 \times 10^{-19}}$ ***C*** ✓

$\boldsymbol{n_e = 0.25 \times 10^{-9}/1.6 \times 10^{-19}}$ ✓

⇨ $\boldsymbol{n_e = 1.56 \times 10^{9}}$ ✓

f) Estimate the force of repulsion that would exist between the positively charged paper going into the drum and the drum itself.

[3 marks]

$\mathbf{F = kq_1q_2/d^2}$ ✓

⇨ $\mathbf{F = 9 \times 10^{9} \times 0.25 \times 10^{-9} \times 0.1 \times 10^{-9}/(1 \times 10^{-3})^2}$

⇨ $\mathbf{F = 2.25 \times 10^{-4}}$ **N**✓✓✓