Scholarship Physics

DC Electricity

1) True or False? … Explain

(i) The terminal voltage across a battery when it is connected to a lamp must be greater than the EMF.

(ii) When a car battery is being charged, The terminal voltage across the battery must be greater than the EMF.

(iii) A galvanometer (very sensitive ammeter) can be used as a voltmeter if a large resistance is connected to it in series.

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(iv) A galvanometer (very sensitive ammeter) can be used as an ammeter if a large resistance is connected to it in parallel.

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2) A high resistance voltmeter is connected to battery. When the battery produces 1.0 A, the voltmeter reads 5.5 V. When the battery produces 2.0 A, the voltmeter reads 5.0 V.

(i) Why should a voltmeter have a high resistance?

(ii) Three one ohm resistors are connected to the battery. Calculate the current

6.0 V

4.0 V

2.0 Ω

R1

0.5 A

3)

(i) Determine the voltage across the middle arm.

 (ii) A 1.0 A current flows through R1. Calculate R1

(iii) Calculate the current in the 3rd battery

(iv) Determine the voltage across the third battery.

(v) The EMF of the third battery is 7.0 V. Calculate its internal resistance.

4) Calculate the three currents.

2.0 V

10 Ω

15Ω

6.0 V

30 Ω

V

3 V

3 Ω

3 Ω

6) Explain what the voltmeter reads when the switch is

 (a) open

(b) closed

3 V

2.0 Ω

3.0 Ω

3.0 Ω

2.0 Ω

A

B

C

D

7) What will a voltmeter read when connected across:

 (a) AB

 (b) BC

 (c) AD

8) All the resistors are 2.0 Ω. A 4.0 V battery is connected across AB. Calculate the battery current.

A

B

9) Put four diodes in the circuit so that the battery can be charged from an AC current

Scholarship Physics

DC Electricity

1) True or False? … Explain

(i) The terminal voltage across a battery when it is connected to a lamp must be greater than the EMF.

*False. The terminal voltage is equal to the EMF minus the voltage drop across the internal resistance. Whenever there is a current flowing, EMF>terminal voltage*

(ii) When a car battery is being charged, The terminal voltage across the battery must be greater than the EMF.

*True. To cause a current to flow backwards into the battery to charge it, the voltage applied must be greater than the EMF*

(iii) A galvanometer (very sensitive ammeter) can be used as a voltmeter if a large resistance is connected to it in series.

*True. Voltmeters must have high resistance as they are connected in parallel with a component The greater the voltage across the component, the more current flows, so the meter can be used to measure the voltage across the component.*

(iv) A galvanometer (very sensitive ammeter) can be used as an ammeter if a large resistance is connected to it in parallel.

*True. Resistors are connected in series with the component so must have low resistance. The shunt resistor has low resistance so most current flows through it.*

2) A high resistance voltmeter is connected to battery. When it produces 1.0 A, the voltmeter reads 5.5 V. When it produces 2.0 A, the voltmeter reads 5.0 V.

(i) Why should the voltmeter have a high resistance?

*See (iii) above*

(ii) Calculate the battery’s EMF and its internal resistance.



(iii) Three one ohm resistors are connected to the battery. Calculate the current



3) (i) Determine the voltage across the middle arm.

 *nb voltage across all three branches must be the same.*

*V = 6 – 0.5 x 2.0 = 5 V*

(ii) A 1.0 A current flows through R1. Calculate R1

*voltage across R1 = 5-4 = 1V*

*R=V/I = 1.0Ω*

(iii) Calculate the current in the 3rd battery

*I = 0.5 0A*

(iv) Determine the voltage across the third battery.

*5.0 V*

(v) The EMF of the third battery is 7.0 V. Calculate its internal resistance.

*2 V drop across internal resistance, so R= V/I = 4.0 Ω*

4) Calculate the three currents.



*(a) There is no voltage across the resistors so using kirchoff’s loop rule,the voltage across the open switch must be 3 V*

*(b) When the switch is closed, its resistance is zero. The voltage across the switch is zero.*

6) Explain what the voltmeter reads when the switch is

 (a) open

(b) closed

3 V

2.0 Ω

3.0 Ω

3.0 Ω

2.0 Ω

A

B

C

D

7) What will a voltmeter read when connected across:

 (a) AB *1.2 V*

 (b) BC *0.6 V*

 (c) AD *3.0 V*

*1.8 V*

*1.2 V*

*1.8 V*

*1.2 V*

8) All the resistors are 2.0 Ω. A 4.0 V battery is connected across AB. Calculate the battery current.

*Circuit is equivalent to two 2.0 Ωs and a 1.0 Ω in parallel. R = 1.0 Ω*

*I = V/R = 4.0 A*

9) Put four diodes in the circuit so that the battery can be charged from an AC current

Scholarship Physics

Capacitors

(1) Sketch graphs of capacitor voltage and resistor voltage/ time.

 Cell voltage = 2.0 V

 Capacitance = 1.0 mF

 Resistance = 1.0 kΩ

(2) Explain what happens to the energy stored in an

air filled capacitor when an insulator is inserted

between the plates.

Where does the energy come from?

(3) A defibrillator needs to deliver 200 J. It is charged to 100 V then discharged through a patient (resistance 100 Ω).

 (i) Calculate the time constant of the circuit.

 (ii) Calculate the voltage after 2 time constants.

 (iii) What happens to the energy stored?

(4) Zoe makes a beer can capacitor. She wraps the can

in paper (dielectric constant 1.5) and wraps aluminium foil

around that. She connects it to a 9.0 V battery.

**Estimate** the charge stored.

 (5) A Van der Graff generator has a capacitance given by:

 

It is charged up to 400 kV

A spark lasts 0.050 s.

(i) Calculate the energy stored. (you need to estimate “R”)

(ii) Calculate the current. Compare it with the current in a torch with a 5.0 W lamp.

X

Y

(6) This array of 1.0 nF capacitors is

 connected at X and Y to a 1.0 V battery at X and Y.

Calculate the energy stored.

(7) Calculate the charge stored in the 3nF capacitor

Explain why the voltage across the 3.0 nF capacitor is smaller than the voltage across the 2.0 nF capacitor.

10.0 V

2.0 nF

3.0 nF

(8) A 2.0μF capacitor is connected to a 6.0 V battery. The capacitor is disconnected and then connected to a 4.0 μF capacitor.

 Explain quantitatively what happens to:

1. the total amount of charge stored.
2. The charge stored on the 2.0μF capacitor
3. the total energy stored.

(9) The change in potential energy for a charge is given by 

 The energy stored in a capacitor is given by 

1. What is the energy stored in terms of charge and voltage?
2. Where does the other  go?

Scholarship Physics

Capacitors

(1)

2V

4s

.63 x 2

.37 x 2

(2) Explain what happens to the energy stored in an

air filled capacitor when an insulator is inserted

between the plates.

Where does the energy come from?

**

*V is constant C has increased so energy increases.*

*Work must be done on the dielectric to push it between the plates*

(3) A defibrillator needs to deliver 200 J. It is charged to 100 V then discharged through a patient (resistance 100 Ω).

 (i) Calculate the time constant of the circuit.



 (ii) Calculate the voltage after 2 time constants.



 (iii) What happens to the energy stored?

It is used to push the electrons through the body. It is converted into heat.

(4) Zoe makes a beer can capacitor. She wraps the can

in paper (dielectric constant 1.5) and wraps aluminium foil

around that. She connects it to a 9.0 V battery.

**Estimate** the charge stored.

*Estimated area = 0.024 m2*

*Estimated separation = 0.0001 mm*

*C= 3.2 x 10-9 F*

*Q=30 nC*

(5) A Van der Graff generator has a capacitance given by: 

It is charged up to 400 kV

A spark lasts 0.050 s.

(i) Calculate the energy stored. (You need to estimate the radius)

*E = ½ CV2 = 1.1 J (taking R as 12 cm.)*

(ii) Calculate the current. Compare it with the current in a torch.



10.0 V

2.0 nF

3.0 nF

(6) This array of 1.0 nF capacitors is

 connected at X and Y to a 1.0 V battery.

Calculate the energy stored.

Total capacitance =2/3 nF

(7) Calculate the charge stored in the 3nF capacitor

Explain why the voltage across the 3.0 nF capacitor is less than the voltage across the 2.0 nF capacitor

*both must store the same charge as they are in series*

*Ctot = 1.2 nF*

*Q = CV = 1.2 x 10-8 C*

*V3nF = Q/C = 4.0 V*

*Because they both have the same charge, the larger capacitor will have a lower voltage.*

(8) A 2.0μF capacitor is connected to a 6.0 V battery. The capacitor is disconnected and then connected to a 4.0 μF capacitor.

6.0V

 Explain quantitatively what happens to:

4 μF

1. the total amount of charge stored.

4 μF

1. The charge stored on the 2.0μF capacitor
2. the total energy stored.

2 μF

1. The total charge can’t change because there is nowhere for it to go or come from.
2. Total charge is 

Both capacitors must have the same voltage across them.

(Q = CV ) so the 2.0μF capacitor will store **half** as much charge, so it stores 8μC

(c) New voltage is V = Q/C = 4V.

total energy was ½ QV = 12 μJ

new total energy is ½ QV = 16 μJ + 32 μJ = 48 μJ

stored energy decreases, its converted into heat in connecting wire

(9) The change in potential energy for a charge is given by 

 The energy stored in a capacitor is given by 

1. What is the energy stored in terms of charge and voltage?

Where does the other  go?It is converted into heat in the connecting wire.