Nature of Electricity

S1-3-04: How does the Atomic Model help to explain static?

Neutral Conservation of Charge Insulator Conductor Polarization

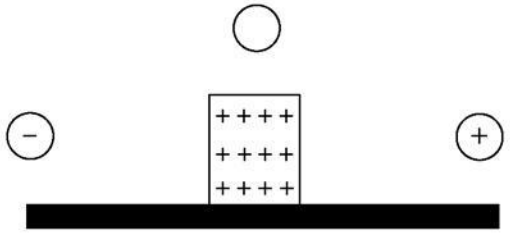
CHARGES and ELECTROSTATICS

S1-3-04: How does the Atomic Model help to explain static?

1. Electrical forces ____.

a. can cause objects to only attract each other
b. can cause objects to only repel each other
c. can cause objects to attract or repel each other
d. have no effect on objects

2. A positively charged object is attached to a table as shown.



Use an arrow to indicate the direction of the force on the negative (−), positive (+), and neutral (no sign) charges placed near the object on the table.

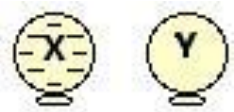
3. Use the words "*increased*" or "*decreased*" to complete each of the following statements:

a. To increase the electric force between two charged objects, the distance separating the two charges should be _____.
b. To increase the electric force between two charged objects, the amount of charge on one or both objects should be _____.
c. To decrease the electric force between two charged objects, the distance separating the two charges should be _____.
d. To decrease the electric force between two charged objects, the amount of charge on one or both objects should be _____.

4. When you rub your feet on the carpet to become "charged", where do the extra negative charges on the come from?

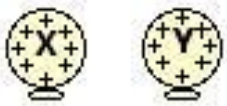
5. Two objects are charged as shown at the right. Object X will ____ object Y.

a) attract b) repel c) not affect



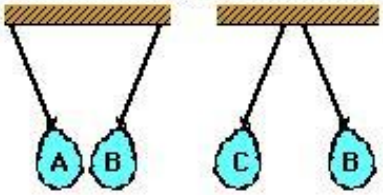
6. Two objects are shown at the right. Object X will ____ object Y.

a) attract b) repel c) not affect



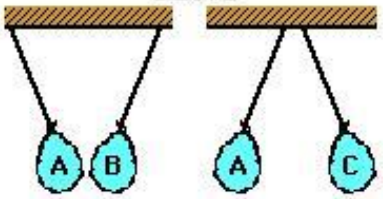
7. On two occasions, the following charge interactions between balloons A, B and C are observed. In each case, it is known that balloon B is charged negatively. Based on these observations, what can you conclusively confirm about the charge on balloon A and C for each situation?

Case #1



Object	Conclusive evidence to conclude the charge is +, - , neutral
A	
B	negative
C	

Case #2



Object	Conclusive evidence to conclude the charge is +, - , neutral
A	
B	negative
C	

8. Complete the sentences using the terms below. Terms may be used more than once:

attracts, negative, neutral, positive, repels, opposite

a. A negative charge is repelled by a _____ charge.

b. A positive charge _____ a negative charge.

c. A charged object _____ a neutral object.

d. A negative object attracts an unknown object. The unknown object could be _____ or _____.

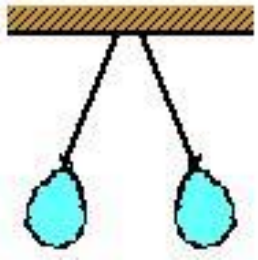
e. A positive object _____ a positive object.

f. If two _____ charges are brought together, they will be attracted.

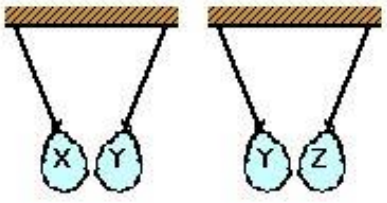
g. If a _____ charged balloon is brought near a positively charged rod, the balloon is attracted to the rod.

9. Upon entering the room, you observe two balloons suspended from the ceiling. You notice that instead of hanging straight down vertically, the balloons seems to be repelling each other. You can *conclusively* say ...

a. Both balloons have a negative charge.
b. Both balloons have a positive charge.
c. One balloon is charge positively and the other negatively.
d. Both balloons are charged with the same type of charge.



10. Balloons X , Y and Z are suspended from strings as shown at the right. Negatively charged balloon X attracts balloon Y and balloon Y attracts balloon Z. Balloon Z ____.
Circle all that apply.
a. may be positively charged
b. may be negatively charged
c. may be neutral



11. Jean Yuss is investigating the charge on several objects and makes the following findings.

	Possible Charge		Possible Charge		Possible Charge		Possible Charge
Object F		**Object C**		**Object D**		**Object E**	
attracts A		attracts B		repels C		attracts D	
						repels F	

Jean knows that object A is negatively charged and object B is electrically neutral. Use the table above to help definitively conclude the charge on objects C, D, E, and F? *Start with A.*.

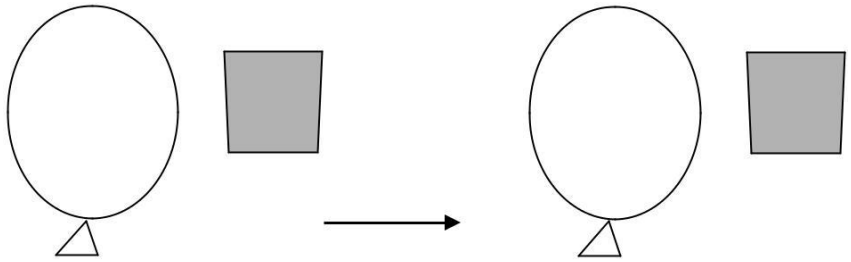
12. Use a check mark to classify the following items as conductors or insulators.

Item	Conductor	Insulator
1. Human body		
2. Air		
3. Wood		
4. Rubber		
5. Plastic		
6. Aluminum		
7. Silver		
8. Wool		
9. Copper		
11. Fur		

13. Why would it be a waste of time to hold a metal strip in your hand and try to charge it by rubbing it with a cloth?

Add the charges to the before and after pictures to show what is happening:

14. POINT ONE: Static electricity needs an insulator. This means that electrons are *not free to move* on the surface.

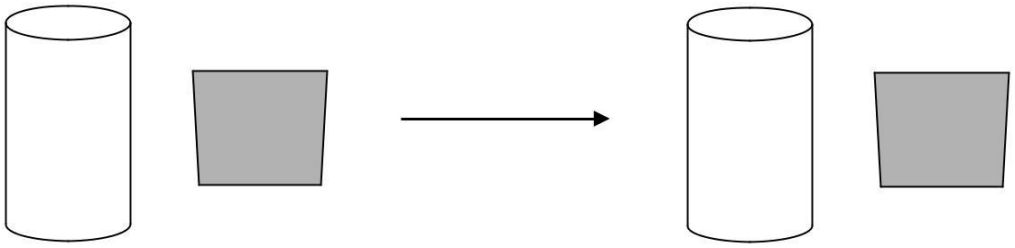


Balloon and cloth **BEFORE** being rubbed together

Balloon and cloth **AFTER** being rubbed together

The build-up of negative charges also called _____ in one place is called static electricity. It is called "static" because it is stuck in place. The negative charges do not move around because they are on a balloon which is made of rubber. Because of this rubber is known as an _____.

15. POINT TWO: Conductors cannot have static electricity. This means that electrons are *FREE to move* on the surface.



Metal rod and cloth **BEFORE** being rubbed together

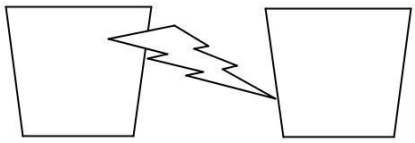
Metal rod and cloth **AFTER** being rubbed together

Metal is a _____, a substance which lets negative charges (also known as _____) move around freely. Because of this, negative charges do not build up in one place, and _____ electricity cannot be created.

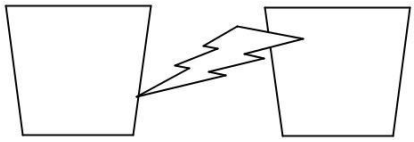
Complete the following diagrams by adding negative charges (electrons) to show the possible relationships:

16. POINT THREE: When there is a difference in negative charges, charges will move.

a.



b.



Negative charges (or electrons) will always move from where there are the (greatest/fewest) number to where there are the (greatest/fewest) number. If there is a big enough difference and the two objects are close enough together, this jumping may cause a _____.

S1-3-11: What is "Electricity" and how is it created?
S1-3-12: What do current, voltage, and resistance mean for electrons?

Electricity Generator Cell Coulomb Voltage Volt Voltmeter Current Ampere/Amp Ammeter Resistance Resistor Ohm Load

GENERATING ELECTRICITY

S1-3-11: What is "Electricity" and how is it created?
S1-3-12: What do current, voltage, and resistance mean for electrons?

1. Identify which sentence applies to static electricity, current electricity or both.

    a) An input of energy is needed.
    b) Will discharge when all charges are transferred.
    c) It is a continuous transfer of a large amount of charge.
    d) Displaced electrons are freely moved through a metal.
    e) Discharges by bringing a neutral or less charged object near.
    f) Involves the direct use of insulators.

2. Look over the main methods of creating current electricity. What are the main ideas necessary for creating a continuous current, regardless of method?

3. How are most large electrical grids (cities) creating their current?

4. What 3 things are necessary for a batteries to create current?

5. What does a coulomb represent, and using formula, show how is it connected to the ideas of voltage and current?

6. What are the measuring devices of voltage and current called? What are the measurement units?

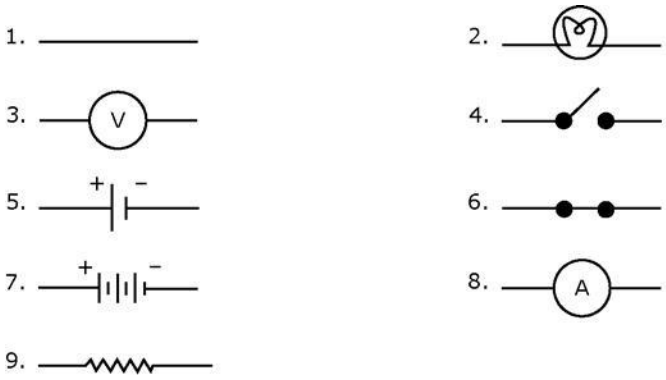
7. Define a load and give some examples of things that would fall under that description.

S1-3-13: What is a schematic and how are they used as information for a circuit?
S1-3-15: What are the similarities and differences between series and parallel circuits?

Battery Switch Series Parallel

SCHEMATICS AND CIRCUITS

S1-3-13: What is a schematic and how are they used as information for a circuit?



1. Identify the above symbols:

1.	2.	3.	4.	5.
6.	7.	8.	9.	

2. Answer the following questions:
   a) What is the difference between a resistor and a load?

   b) What three things are needed for a basic circuit?

   c) What is a switch?

3. Draw the schematics for each circuit with the identified parts (show the direction of current flow in all circuits):

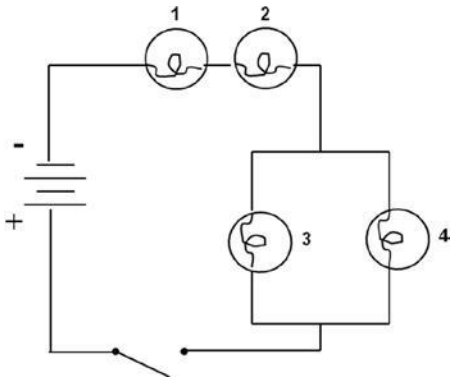
1.5 volt (V) cell		3.0 volt (V) battery	
light bulb		2 light bulbs *(in series)*	
switch		switch	
		ammeter	
1.5 V cell		2 - 1.5 V cells	

		(series)	
2 bulbs *(in parallel)*		2 bulbs *(parallel)*	
switch that turns off both bulbs		voltmeter across one bulb	
6.0 V battery		3.0 V battery	
3 light bulbs *(parallel)*		2 motors *(series)*	
resistor *(series w/ bulbs)*		switch that turns off both motors	
		ammeter	
3.0 V battery		4.5 V battery	
2 loads *(series)*		3 light bulbs *(series)*	
switch		switch	
resistor *(parallel w/ loads)*		voltmeter across the battery	
ammeter			
4.5 V battery			
1 light bulb *(series w/ battery)*			
voltmeter across the bulb			
ammeter that measures all current in the circuit			
2 resistors *(parallel)*			
a switch that turns off one resistor only			

SERIES VS PARALLEL

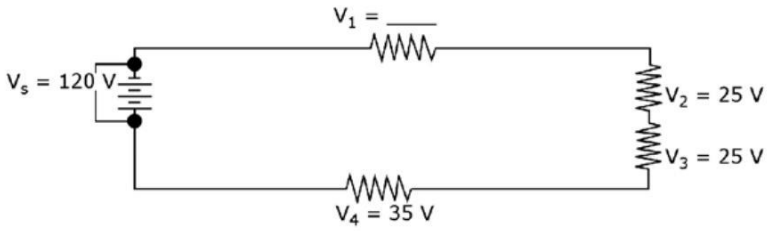
S1-3-17: What are the similarities and differences between series and parallel circuits?

4. Predict which bulbs are lit in this circuit under the following situations. You can just circle your answer for each bulb in each situation.

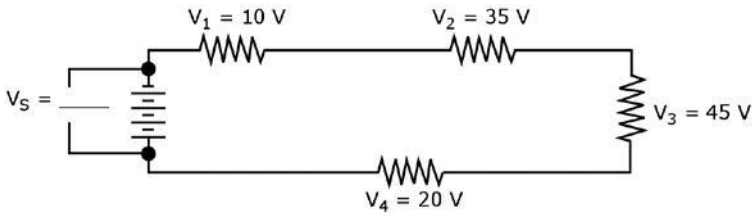


a) The circuit is open	Bulb 1: off on Bulb 2: off on Bulb 3: off on Bulb 4: off on
b) The circuit is closed and bulb 3 is unscrewed.	Bulb 1: off on Bulb 2: off on Bulb 3: off on Bulb 4: off on
c) The circuit is closed and bulb 2 is unscrewed.	Bulb 1: off on Bulb 2: off on Bulb 3: off on Bulb 4: off on

5. Calculate the missing values in the circuits below. Show your calculations.

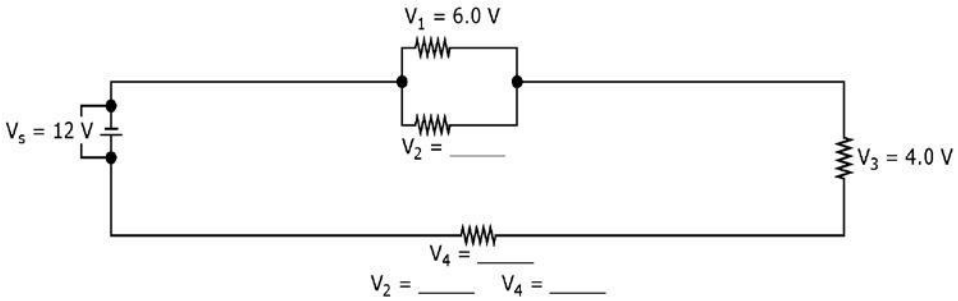


V_1 =



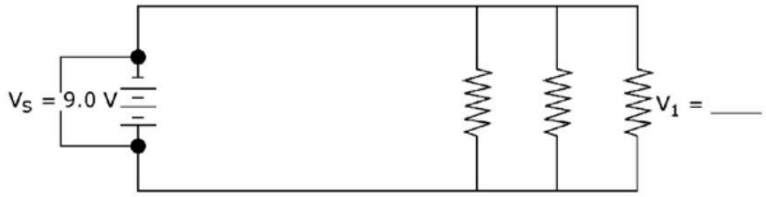
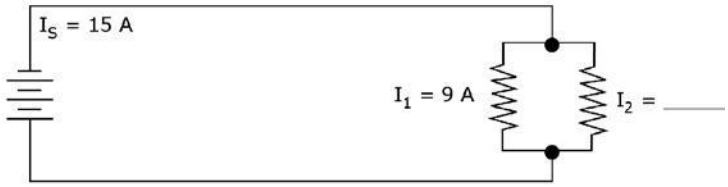
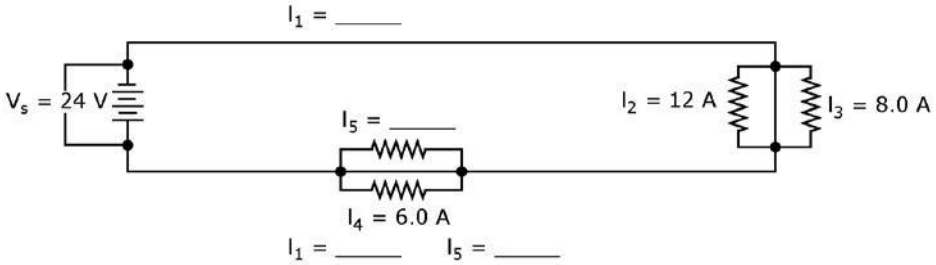
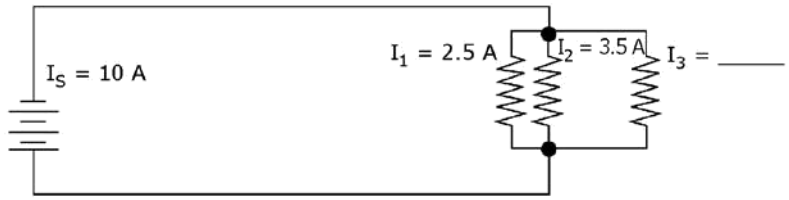
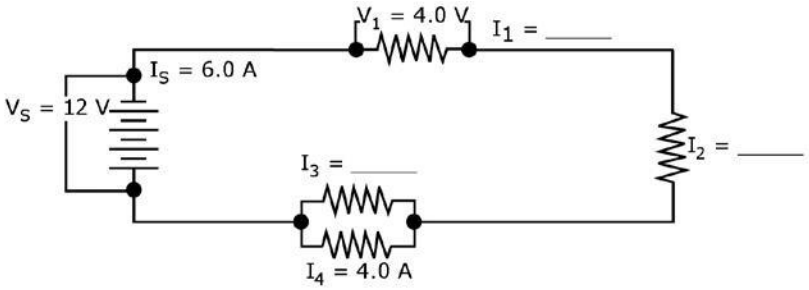
(Vs is the total / "source" voltage)

Vs =

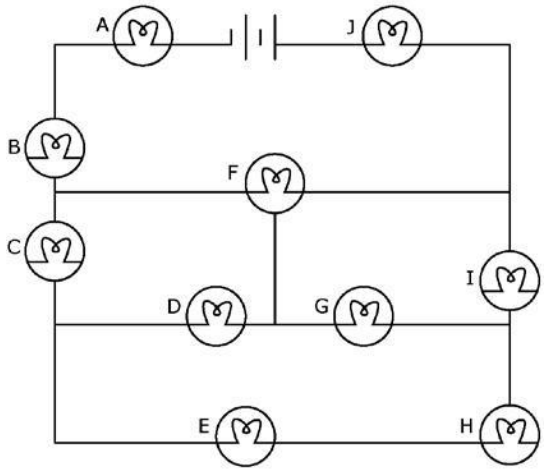


V_2 =

V_4 =

	V_1 =
	I_2 =
	I_1 = I_5 =
	I_3 =
	I_1 = I_2 = I_3 =

6. Use the circuit diagram below:



List two bulbs that are connected in series. _____

List three bulbs that are connected in series. _____

List two bulbs that are connected in parallel. _____

List two other bulbs that are connected in parallel._____

7. Circle the best term in the brackets to correctly complete each statement.
   a) A parallel circuit has *(only one / more than one*) path for current to travel.

   b) Two different resistors are connected in parallel. The current through one of the resistors will be *(equal to / different from)* the current through the other resistor.

   c) If two different resistors are connected in parallel, the voltage across one resistor will be *(equal to / different from)* the voltage across the second resistor.

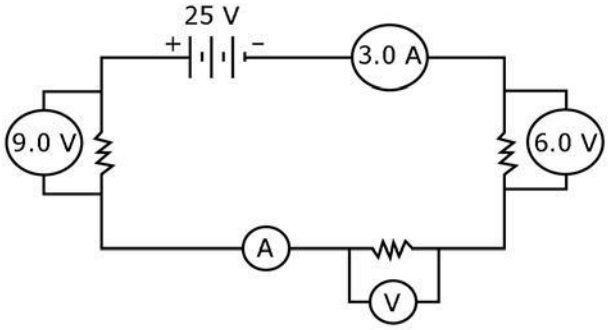
   d) By adding a resistor in parallel with an original resistor, the total resistance of the circuit *(increases / decreases).*

   e) The total current entering the junction of a parallel circuit must be *(equal to / different from)* the sum of the currents through each branch of the parallel circuit.

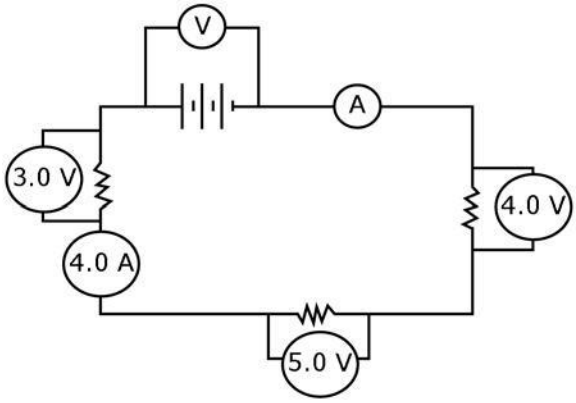
8. If a standard cell creates 1.5 volts of potential energy, how is an electric car able to produce 12 V of potential using cells?

Find the missing voltage at V, and current at A, and the total circuit Resistance in each of the following:

1. Voltage = _____ Current = _____



2. Voltage = _____ Current = _____



3. Indicate and explain whether you would connect cells in series or parallel to do the following.
   a. increase current

   b. increase voltage

4. For the following circuits, indicate whether the bulb(s) will be normal brightness, ½ brightness, or 2x brightness. *(One cell, connected to one bulb is NORMAL brightness)*

   a. One cell, two bulbs in series.

   b. One cell, two bulbs in parallel.

   c. Two batteries in series, two bulbs in series.

   d. Two batteries in parallel, two bulbs in parallel.

5. Complete each table by ***circling the best term*** in each set of the brackets.

SERIES

Question	Answer
Number of paths	(*one / multiple*)
Effect of removing a load	The circuit is opened. Electrons (can / cannot) flow.
Voltage or potential drop	The sum of voltage lost in the ENTIRE circuit is (*less than / equal to / greater than*) the total voltage supplied by the battery.
Current	The current (*varies / is the same*) throughout the circuit.
Resistance	• When placed in series, the total resistance of the circuit is (*decreased / unchanged / increased*). • When the total resistance is (*decreased / increased*), the total current will (*decrease / increase*).
Cells in series	• Total voltage is the (*sum of / same as*) the voltages of each of the individual cells. • Maximum lifespan of the battery is (*less than / the same as / greater than*) the lifespan of each of the individual cells.

PARALLEL

Question	Answer
Number of paths	(*one / multiple*)
Effect of removing a load	The circuit is opened. Electrons (can / cannot) flow.
Voltage or potential drop	The sum of the voltage lost in EACH BRANCH of the circuit is (*less than / equal to / greater than*) the total voltage of the battery.
Current	• The total current entering or leaving a junction is (*the sum of the current in all of the paths / the same as the current in one of the paths*).
Resistance	• When placed in parallel, the total resistance of the circuit is (*decreased / increased*).
Cells in parallel	• Total voltage is the (*sum of / same as*) the voltages of each of the individual cells. • Maximum lifespan of the battery is (*less than / the same as / greater than*) the lifespan of each of the individual cells.

S1-3-18: How is a household wired to ensure safety?
S1-3-20: What is electrical power and how does it vary in appliances?
S1-3-22: How can you lower electrical energy use of a household?

Short circuit Overload Circuit breaker Fuse Power kWh Efficiency EnerGuide

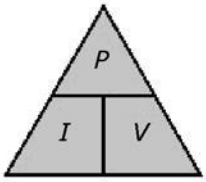
POWER AND ENERGY

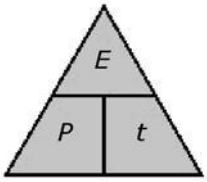
S1-3-18: How is a household wired to ensure safety?
S1-3-20: What is electrical power and how does it vary in appliances?

Calculating power of an electrical device can be done using *2 formula.*

Power is energy consumption of a device over time used:
P = E ÷ t, where P is in **watts (W)**, E is in **Joules (J)**, and t is in **seconds (s)**.

It is more common to talk about the voltage and current rather than energy and time:
P = V·I, where P is in **watts (W)**, V is in **volts (V)**, and I is in **amperes (A)**.





Find the correct formula. Plug in the number. Make sure you include the units.

1. Find the unknown quantity:

a) E = 10 J P = 100 W t = ?	b) E = 1.2 kJ = _____ J P = ? t = 16 s	c) E = 55 J P = ? t = 1.5 hrs = _____ s
a) P = 100 W I = ? V= 6.7 V	b) P = 150 W I = 750 mA = _____ A V = ?	c) P = ? I = 10 A V = 1.2 kV = _____ V

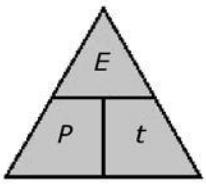
2. A flashlight bulb operates on 3.0 V and draws a current of 4.0 A. What is the power of this bulb?

3. A 60 W light bulb is connected to 120 V. What current passes through the light bulb?

4. A circuit draws a current of 25 mA from a 12 V battery. What is the power output of this battery?

5. A 0.20 A current passes through a 450 Ω resistor. Calculate the electric power "lost" in this resistor. (Hint: Use Ohm's law to find the voltage.)

We rearrange the second equation to get E = Pt, where E is measured in joules (watt · seconds), or express the energy using the larger unit of kilowatt-hours (kW·h)*



6. How much energy, in joules, is consumed by a 1400 W hair dryer if it is used for 10 min?

7. How much energy, in kilowatt·hours (kWh), is consumed by a 200 W stereo if it is left on for 4.0 h?

8. What is the power rating of a toaster that uses 210 000 J of energy while toasting bread for 140 s?

9. How much energy (in kWh) is consumed by a 750 W air conditioner if it is left on for 24 h?

ANSWER KEY

2. 12 W **3. 0.5 A** **4. 0.30 W** **5. 18 W**

6. 8.4×10^5 J **7. 0.8 kWh** **8. 1500 W** **9. 6.48×10^7 J or 18 kW•h**

ENERGY CONSUMPTION

S1-3-22: How can you lower electrical energy use of a household?

1. A meter reader determines that a business used 3550 kWh of energy in two months. At a cost of 10 cents per kWh, calculate the bill.

2. An electric heater draws 1100 W of power. Electricity costs 8 cents per kWh. How much does it cost to operate the heater 3.0 h a day for 30 days?

3. A 730 W toaster and 1200 W electric frying pan are plugged into the same 100 V outlet. How much will it cost to operate the two appliances at 8 cents per kWh if they are used for 20 h?

4. A toaster is used an average of 5.0 hours a month. The toaster draws 8.0 A of current from a 110 V outlet. If electricity costs 8 cents per kWh, how much will it cost to operate the toaster for one year?

5. A 240-volt electric water heater uses an average of 4800 watts over a period of four hours in one day.
   a. What is the energy consumption for the day (joules and kWh)?

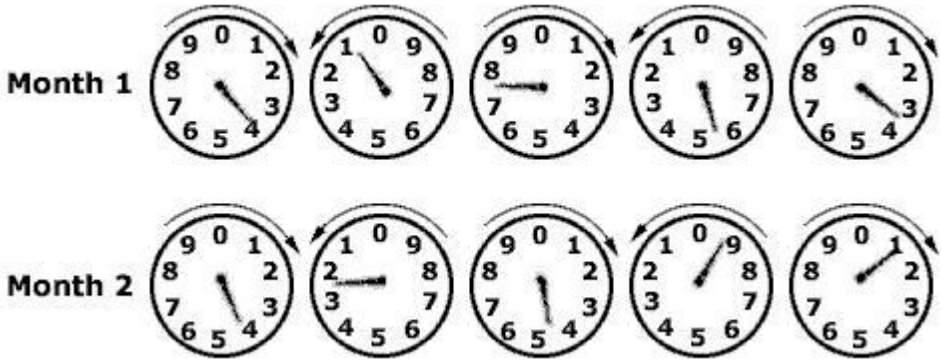
   b. If energy costs are $0.11 per kilowatt-hour, what is the cost of operating the heater for the day?

ANSWER KEY

1. $355.00 **2. $7.92** **3. $3.09** **4. $4.22**

5. 6.9×10^7 joules, 19.2 kWh, $2.11

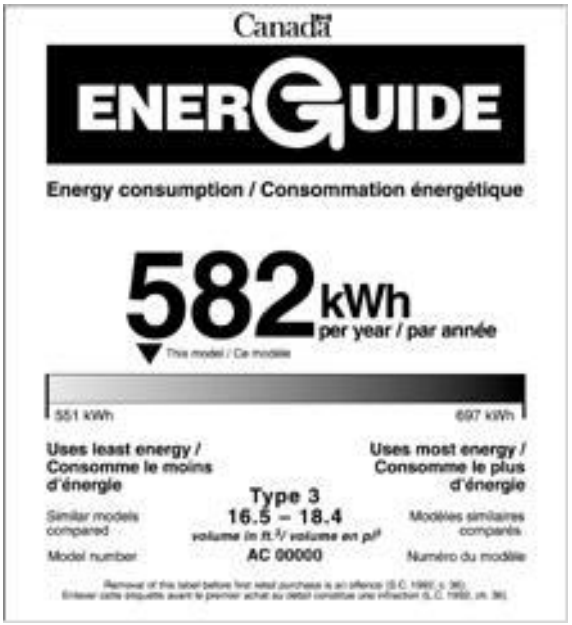
6. Use the diagram of the two meter readings to answer the questions below.



a) What is the reading for each of the months represented in the diagram?

b) How much electrical energy was consumed according to the readings?

7. Use the Energuide sticker below to answer the questions.



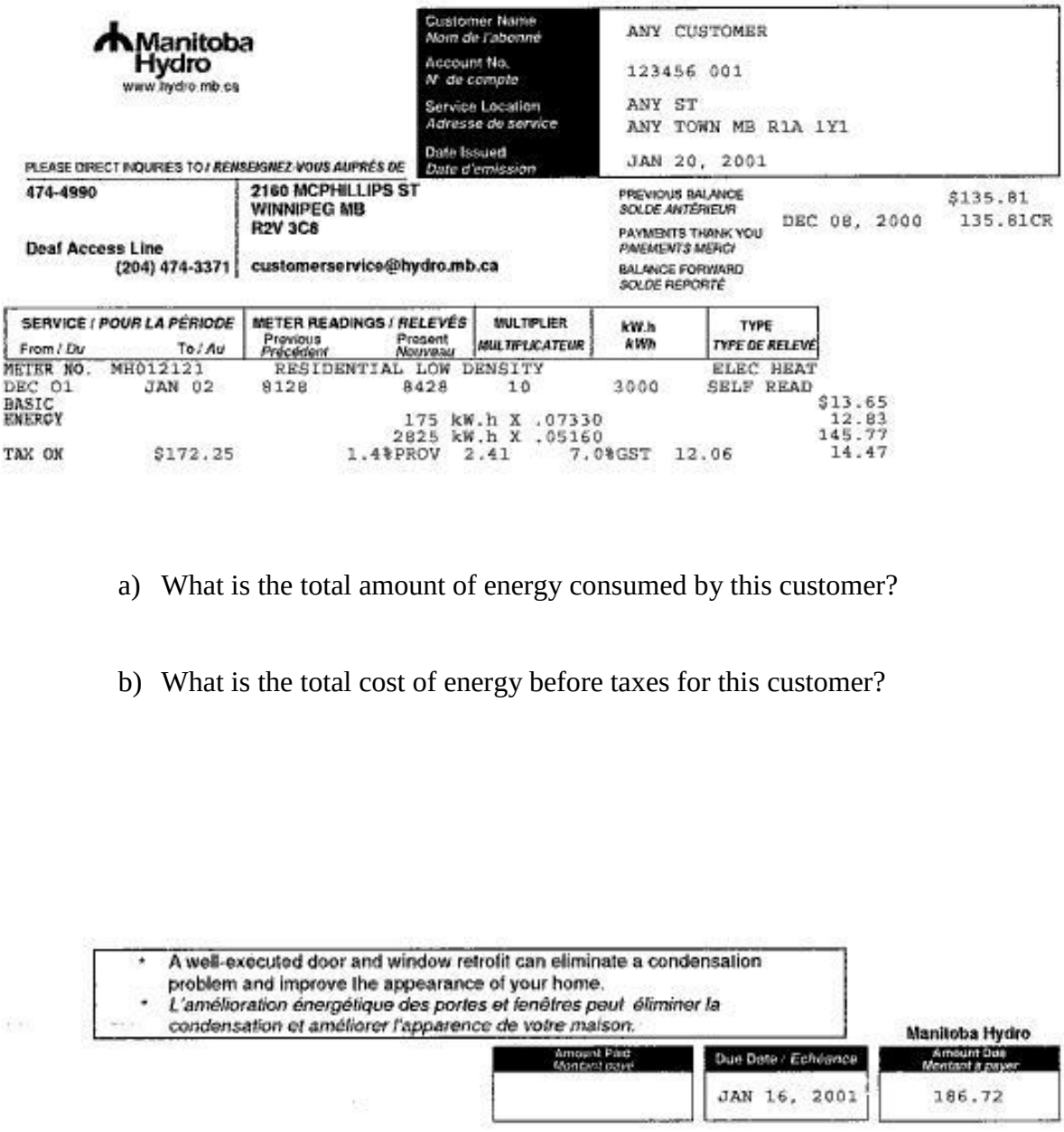
a) How much energy would you expect to use in a year with this appliance?

b) What is the lowest and highest energy consumption for this type of appliance?

c) If the electricity you used cost 4.7 cents per kWh, what is the average cost per month when using the appliance?

8. List four modifications that you and your family could use to reduce energy consumption?

9. Use the example electric bill to answer the following questions.



Manitoba Hydro
www.hydro.mb.ca

Customer Name / Nom de l'abonné	ANY CUSTOMER
Account No. / N° de compte	123456 001
Service Location / Adresse de service	ANY ST ANY TOWN MB R1A 1Y1
Date Issued / Date d'émission	JAN 20, 2001

PLEASE DIRECT INQUIRIES TO / RENSEIGNEZ-VOUS AUPRÈS DE

474-4990

Deaf Access Line
(204) 474-3371

2160 MCPHILLIPS ST
WINNIPEG MB
R2V 3C8

customerservice@hydro.mb.ca

PREVIOUS BALANCE / SOLDE ANTÉRIEUR		$135.81
PAYMENTS THANK YOU / PAIEMENTS MERCI	DEC 08, 2000	135.81CR
BALANCE FORWARD / SOLDE REPORTÉ		

SERVICE / POURE LA PÉRIODE From / Du	To / Au	METER READINGS / RELEVÉS Previous / Précédent	Present / Nouveau	MULTIPLIER / MULTIPLICATEUR	kW.h / kWh	TYPE / TYPE DE RELEVÉ	
METER NO. MH012121		RESIDENTIAL LOW DENSITY				ELEC HEAT	
DEC 01	JAN 02	8128	8428	10	3000	SELF READ	
BASIC							$13.65
ENERGY			175 kW.h X .07330				12.83
			2825 kW.h X .05160				145.77
TAX ON	$172.25	1.4%PROV	2.41	7.0%GST	12.06		14.47

- A well-executed door and window retrofit can eliminate a condensation problem and improve the appearance of your home.
- *L'amélioration énergétique des portes et fenêtres peut éliminer la condensation et améliorer l'apparence de votre maison.*

Manitoba Hydro

Amount Paid / Montant payé	Due Date / Échéance	Amount Due / Montant à payer
	JAN 16, 2001	186.72