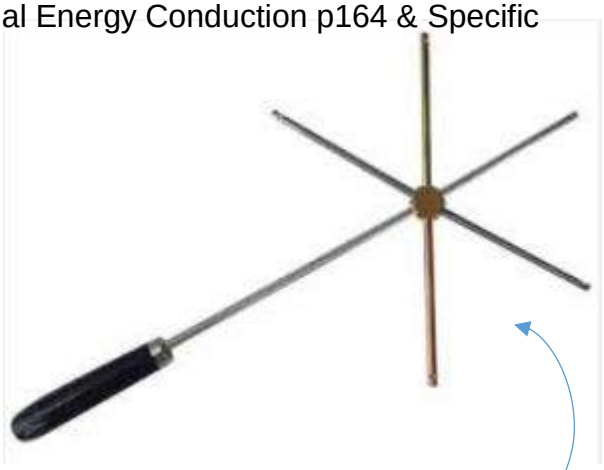
Name _____ per_____ date_____ mailbox_____

Heat Conductometer - Handel w/ Metal Spokes!

Reference & background reading: Transferring Thermal Energy Conduction p164 & Specific Heat p161

Materials:

- *1 Conductometer*
- *Wax chips*
- *Candles*
- *Goggles*
- *Stop watches*
- *Match heads – optional*



Label: **central hub & spoke**

Reading:

There are several methods of determining the diverse conductivity of metals using the spoke type conductometer. In each method, heat is applied to the central hub. The heat flows out along the spokes of each metal to the ends. Some heat is consumed in raising the temperature the metal of the spokes, some heat is lost to the air through convection and some simply radiates away as radiation. The heating of the spokes leading to the wax melting involves more than just thermal conductivity of the metal alone. It involves three factors; *atomic mass* of the metal, *specific heat* and *conductivity* of the individual metals.

To demonstrate the conduction of heat from the aluminum central hub to the ends of the spokes, we will place a chip of wax in the curvatures near the end of each spoke. You will want to make sure that each little curvature or dimple gets a tiny chip or ball of wax. The spokes which conduct heat the best, will melt their wax chips first. Another method is to place match heads in the curvature at the end of each spoke. The matches should ignite in order of the metal with the lowest specific heat, to the metal with the highest. The property of metals' ability to conduct heat is demonstrated with this simple experiment during our lab.

As a matter of student interest, you may like to note the position in the periodic table of the *good* heat conductors of lower specific heats verses the poorer ones with higher specific heats. In metals, thermal conductivity is highest in the metals having a large number of free electrons such as the group 1 elements. Alloys of these metals with a member of group 6, 7 or 8 are usually very poor conductors and even lower than the group 6, 7, or 8 metals in their pure form alone.

Source (Morris and Lee Co.)

Prelab /PREP QUESTIONS:

1. A range of **conductivities** exist for various substances**.** True or False

2. The heat energy required to raise the temperature of 1 unit of a substance 1 degree Celsius is referred to as **specific heat.** True or False

3. Another way to think about **specific heat** is the amount of thermal energy a substance can retain and hold onto for a period of time. True or False

4. In your own words what is **specific heat.**

_____

_____

_____

_____

5. What are 3 factors that could affect the amount of heat energy that is transferred along each metal spoke? (read cover of lab)

_____

_____

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_____

6. Define the term **alloy** from the glossary in your Physical Science Textbook or use Google, your text or other resource. Which metals from were alloys?

_____

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_____

7. Which metals from were alloys?

_____

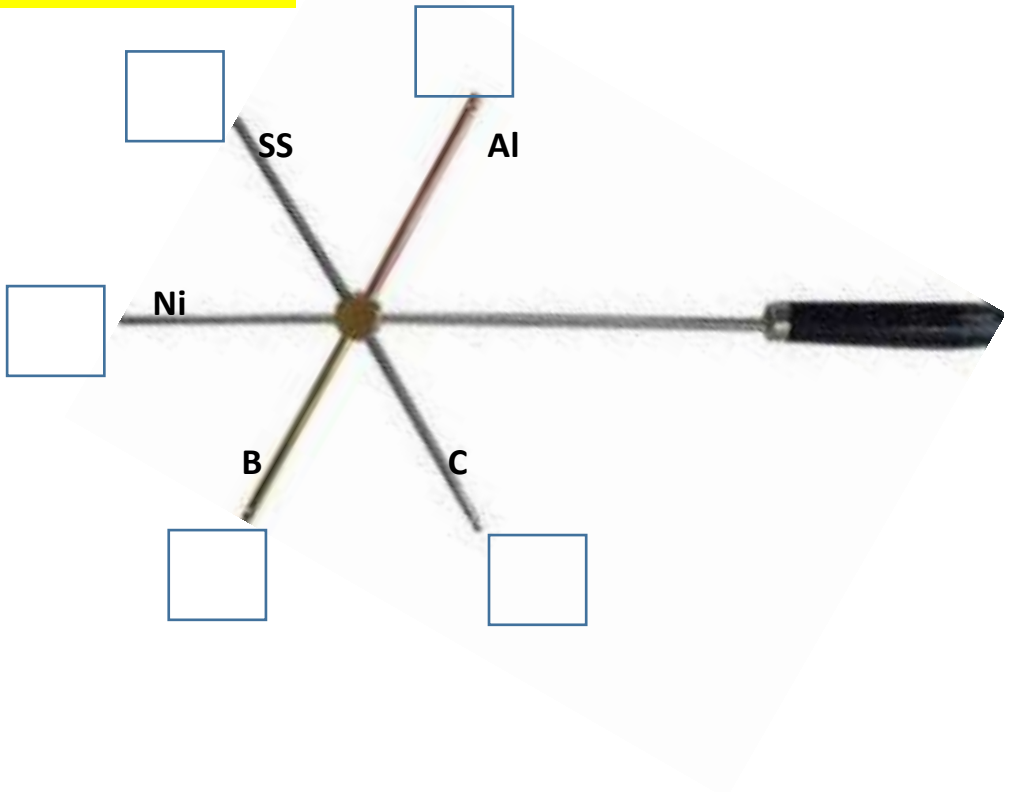
Reference Table:

Metal	Hub Marking	Conductivity	Specific Heat	mass of the spoke
			J/ g deg. C	grams
Copper	CU	1.00	0.39	3.23 g
Brass – Cu & Zn	BS	0.26	0.38	3.08 g
Nickel	NI	0.14	0.44	3.21 g
Iron	FE	0.11	0.45	2.84 g
Stainless Steel	SS	0.04	0.46 - 0.502	2.8 g
Aluminum	Al	0.50	0.90	0.98 g

Stainless Steel - Fe, Cr, Ni

Consider the reference data above. Debate, discuss and create a hypothesis by labeling the spokes in the order you think the wax will melt.

PREDICTIONS PAGE:



PROCEDURE:

- ☐ 1. Setup lab table groups & load wax into conductometer
- ☐ 2. Safety check: all loose clothing tucked in and hair tied up, goggles on etc.
- ☐ 3. Assign group leader, safety boss, stop watch boss, wax loader, data quality assurance controller, data recorder
- ☐ 4. SAFTEY – conductometer is going to get **HOT!** Be aware of your surroundings. Where will you set it down when done? How will YOU assure no one gets burned? (WRITE)_____
  _____
  _____

DATA:

1. Be sure and verify the various metal elements or alloys that **your conductometer** has.
2. The **label the metal spokes** as they appear on the central hub below on diagram.
3. Place lit candle under the central hub.
4. With careful observation record the order 1,2,3,4,5 in which the wax melts.
5. Simply **write on this page 1-2-3-4-5** next to each spoke in the proper order with label.
6. Extend – stop watch timer data

Label each metal or alloy **5pts**
Record the order by numbering each spoke clearly 1-5, when wax starts to melt **5pts**

Reference Table:

Metal	Hub Marking	Conductivity	Specific Heat	mass of the spoke
			J/ g deg. C	grams
Copper	CU	1.00	0.39	3.23 g
Brass	BS	0.26	0.38	3.08 g
Nickel	NI	0.14	0.44	3.21 g
Iron	FE	0.11	0.45	2.84 g
Stainless Steel	SS	0.04	0.46 - 0.502	2.8 g
Aluminum	Al	0.50	0.90	0.98 g

Lab write up Q's

Calculate the thermal energy required to melt each of the wax balls at the ends of each of the spokes in your group's conductometer. Assume the class room is 20^0C and that the wax melts at 37^0C. Check classroom thermometer for more accurate room temperature data. Use the reference table above for specific heat and mass data regarding each of the metals and the spokes.

1. Clearly list the proper formula
2. Substitute in the proper numbers
3. Box answer w/ proper units & label the METAL

1. List formula	**substitute values**	**answer w/ units**	**metal label**
2. List formula	**substitute values**	**answer w/ units**	**metal label**
3. List formula	**substitute values**	**answer w/ units**	**metal label**

4. List formula	substitute values	answer w/ units	metal label

5. List formula	substitute values	answer w/ units	metal label

Just in case:

Written thought questions Post lab Qs

DATA TABLE (A):

Metal	Hub Marking	Thermal Energy	Specific Heat	Conductivity
		Joules (J)	J/ g deg. C	
Copper	CU		0.39	1.00
Aluminum	Al		0.38	0.50
Brass	BS		0.44	0.26
Nickel	NI		0.45	0.14
Iron	FE		0.46 - 0.502	0.11
Stainless Steel	SS		0.90	0.04

Write down the thermal energy needed to melt the wax for each metal.

1. Does there appear to be any **relationship** between the thermal energy calculated in **DATA TABLE (A):** between thermal energy and specific heat or between thermal energy and conductivity. Describe this relationship between these properties.

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Written thought questions Post lab Qs

DATA TABLE (B):

Metal	Hub Marking	Order they melted	Conductivity
Copper	CU		1.00
Aluminum	Al		0.50
Brass	BS		0.26
Nickel	NI		0.14
Iron	FE		0.11
Stainless Steel	SS		0.04

Write the number for the order in which the wax melted for each metal.

4. What kind of **relationship** do you observe from your **DATA TABLE (A):** between, Conductivity & the order in which the wax melts? Does the wax melt faster or slower based on conductivity?

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DATA TABLE (C):

Metal	Hub Marking	Atomic Mass	Conductivity
Copper	CU		1.00
Aluminum	Al		0.50
Nickel	NI		0.14

Write the atomic mass for each metal. See attached Periodic Table

5. What **relationship** might you infer from your Conductivity & Atomic Mass **DATA TABLE (B)?**

_____

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MAKING SCIENCE LAB RELEVANT:

Directions: watch *Brilliant Newfoundlander Invents the Solution!* https://youtu.be/bRZvAAqzXIw

A. What does the invention do?

_____

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_____

B. Discuss a type of heat energy it uses and **explain how**?

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C. Why are aluminum cans such a great idea for this invention? Use the words **specific heat and conductivity**

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Periodic Table of the Elements

1 IA 11A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.09	35 Br Bromine 79.904	36 Kr Krypton 84.80
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 168.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

Lanthanide Series	57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Alkali Metal | Alkaline Earth | Transition Metal | Semimetal | Nonmetal | Basic Metal | Halogen | Noble Gas | Lanthanide | Actinide