Part D: Change of State and Temperature

Substance	**Melting/Freezing point**	**Boiling/Condensing Point**
Water (H_2O)	0℃	100℃
Nitrogen (N_2)	−210℃	−196℃
Oxygen (O_2)	−219℃	−183℃
Iron (Fe)	1538℃	2862℃
Mercury (Hg)	−39℃	357℃
Copper (Cu)	1085℃	2562℃

At each temperature, will each substance be a solid, liquid, or gas?

	−270℃	**−200**℃	**−100**℃	**22**℃	**150**℃	**500**℃	**1500**℃	**2000**℃	**3000**℃
Water (H_2O)									
Nitrogen (N_2)									
Oxygen (O_2)									
Iron (Fe)									
Mercury (Hg)									
Copper (Cu)									

Part E: Temperature and state of water:

Rule #1 Liquid water *cannot* have a temperature less than 0°C or greater than 100°C.
Rule #2 When changing state (freezing, boiling, melting, or condensing), water (or anything else) does not change temperature.
Ruler #3 Water cannot be less than 0°C without freezing into ice first. Ice cannot have a temperature greater than 0°C without turning into water first. Freezing water or melting ice *always* has a temperature of 0°C. It cannot be anything else.
Rule #4 Water cannot be greater than 100°C without boiling into vapor first. Vapor cannot be less than 100°C without condensing into water first. Boiling water *always* has a temperature of 100°C. It cannot be anything else.

E.1:
A bowl of water has a temperature of 22°C.
You put a bowl of water in a freezer. The freezer temperature is −18°C.

E.1a. An hour later, you check the freezer the bowl is still water, not ice.
What temperature is it? Why?
A. −18°C.
B. somewhere between −18°C. and 0°C
C. 0°C
D. somewhere between 0 C and 22°C
E. 22°C

E.1b. Three hours later, you check the freezer the bowl is partly ice and partly water.
Assume the temperature of the bowl is uniform (all the same).
What temperature is it? Why?
A. −18°C.
B. somewhere between −18°C. and 0°C
C. 0°C
D. somewhere between 0 C and 22°C
E. 22°C

E.1c. Three days later, you check the freezer and the bowl is entirely ice. What temperature is it? Why?
What temperature is it?
A. −18°C.
B. somewhere between −18°C. and 0°C
C. 0°C
D. somewhere between 0 C and 22°C
E. 22°C

E.2 What temperature is a cup of ice water, in which the ice is slowly melting?

E.3 What temperature is a pot of boiling water?

Rule 5:

Dissolving salt in water *increases the boiling temperature* and *decreases the melting temperature*.

E.4 To cook pasta, you need to put it in boiling water. The hotter this water, the faster the pasta cooks.
You can cook pasta faster if you dissolve salt in the water. Why?

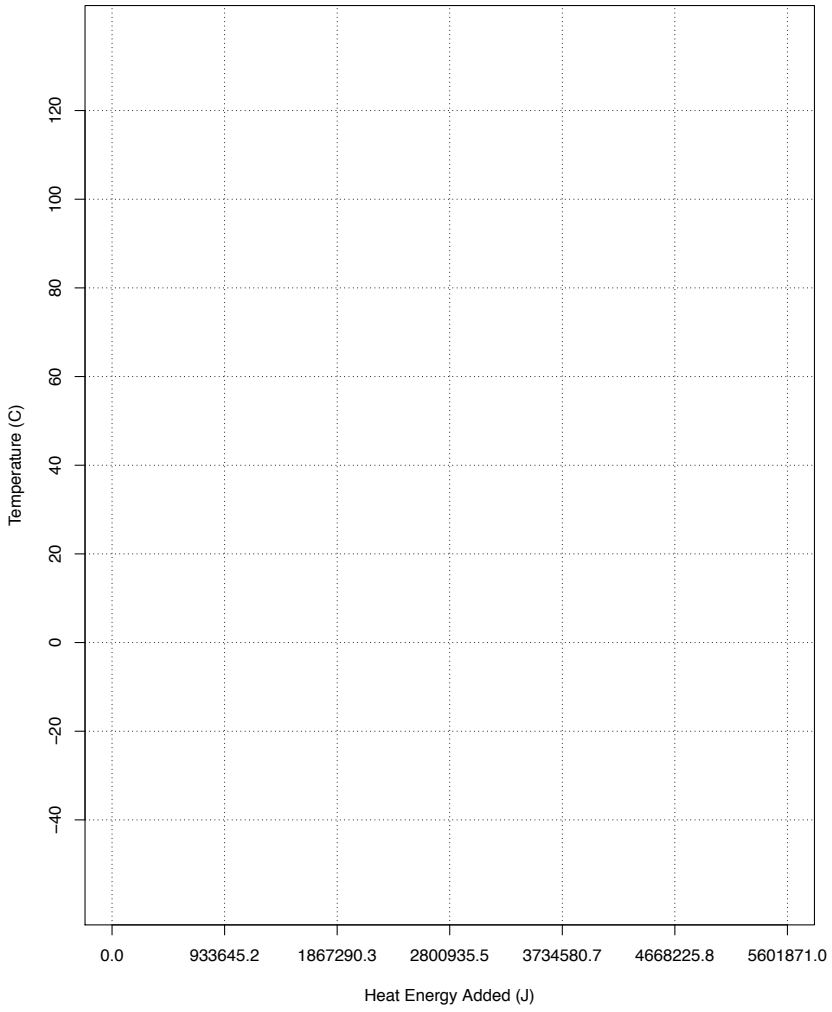
E.5 To melt ice on roads in the winter, they cover the roads with salt. Why?

E.6
Temperature is "average molecular kinetic energy"
A bowl of water is at 20 degrees Celsius.
The air in the room is at 20 degrees Celsius.
All three are in *thermal equilibrium*.
Which has the greatest average molecular kinetic energy?
Which has the lowest average molecular kinetic energy?

Part F: Heat Energy Graphs

F.1

Create a Heat Energy Graph for H_2O as it is heated from -40°C to 120°C.
The graph will have 5 sections. For each section, label which *state of matter* or mixture thereof the H_2O is in.
Remember that *temperature does not change* while state changes.



F.2
The melting point for iron is 1811 K.
The boiling point for iron is 3134 K.

Imagine you have a certain amount of solid iron at 300 K.
You continually add heat energy until you have gaseous iron at 400 K.

Draw a pair of axes. On the X-axis should be 'heat energy added.' On the Y-axis should be 'temperature.

Show how the temperature of the iron changes when you add heat energy. On your graph, label when the iron is *solid*, *liquid*, *gas*, *melting*, and *boiling*.

Properties of states of matter Name _____

Answer

	-300℃	-200℃	-100℃	22℃	150℃	500℃	1500℃	2000℃	3000℃
Water (H_2O)	S	S	S	L	G	G	G	G	G
Nitrogen (N_2)	S	L	G	G	G	G	G	G	G
Oxygen (O_2)	S	L	G	G	G	G	G	G	G
Iron (Fe)	S	S	S	S	S	S	S	L	G
Mercury (Hg)	S	S	S	L	L	G	G	G	G
Copper (Cu)	S	S	S	S	S	S	L	L	G

1a. Answer, D
water *cannot cool* below 0 without turning into ice first. Period.

1b. Answer: C
If the water is currently in the process of freezing, it must be at its boiling point

1c. Answer: A
By this point, it has completely frozen and reached thermal equilibrium with the freezer.

2. 0℃

3. 100℃

ANSWER:
They all have the same!
It just happens that, metal, at 20 degrees, is able to remain a solid with atoms attached.
Water is in the liquid state at this temperature
Air is a gas at this temperature