Don't Freeze the Engine

NAME _____

Antifreeze is used in a car's cooling system to protect the engine from freezing at various temperatures. In this activity, you will use an antifreeze chart to determine how much fluid in a vehicle's cooling system should be replaced with antifreeze to achieve a desired level of protection.

The antifreeze chart below shows how many quarts of antifreeze are needed, based on the cooling system capacity, to protect a car at various temperatures (in ºF).

Cooling System Capacity (Quarts)	Quarts of Antifreeze Required for Protection to the Given Temperature											
	1	2	3	4	5	6	7	8	9	10	12	13
8				-34								
9	24	14	0	-21	-50							
10	25	16	4	-12	-34	-62						
11	26	18	8	-6	-23	-47						
12		19	10	0	-15	-34	-57					
13		21	13	3	-9	-25	-45	-66				
14			15	6	-8	-18	-34	-54				
15			16	8	0	-12	-26	-43				
16			17	10	2	-8	-19	-34				
17			18	12	5	-4	-14	-27				
18			19	14	7	0	-10	-21	-34	-50	-65	
19			20	15	9	2	-7	-16	-28	-42	-65	
20				16	10	4	-3	-12	-22	-34	-48	-62

Part 1: Reading the Chart

1. Determine how much antifreeze is needed to protect an engine with the following system capacity at the given temperatures.

System Capacity	Temperature	Quarts of Antifreeze Needed
18 quarts	-10ºF	
15 quarts	0ºF	
10 quarts	16ºF	
15 quarts	-43ºF	

Part 2: Getting the Right Mix

A 20-quart cooling system currently has a mix of water and antifreeze to protect the engine to temperatures as low as 10ºF.

2. Complete the following chart using the above information and the antifreeze chart. (For the rest of this activity, this information will help you determine how to adjust the fluid in the current system to obtain protection as low as -48ºF.)

NUMERICAL ANALYSIS OF THE SYSTEM		EXPLAIN HOW YOU KNOW
Cooling System Capacity (Quarts)		
Current Level of Protection (Temperature)		
Current Amount of Antifreeze (Quarts)		
Current Amount of Water (Quarts)		
Percent Concentration of Antifreeze in the System (%)		
Percent Concentration of Water in the System (%)		
Antifreeze Needed for Target Protection Level (Quarts)		
Water Needed for Target Protection Level (Quarts)		
Percent Concentration of Antifreeze Needed for Target Protection Level (%)		

3. When fluid is drained from a cooling system, some of the fluid is water and some of the fluid is antifreeze, depending on the percent concentration.

Refer to the current percent concentration of the system in Question 2. When the following amounts of fluid are drained from a 20-quart system at a 10°F level of protection, how many quarts of water are drained, and how many quarts of water remain in the system? Complete the following chart.

QUARTS OF **FLUID DRAINED** FROM 20-QUART SYSTEM	QUARTS OF **WATER DRAINED** FROM 20-QUART SYSTEM	QUARTS OF **WATER REMAINING**
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		

4. The cooling system in Question 2 has a 20-quart capacity and protection to 10°F. Approximately how many quarts of fluid should be drained to leave the desired amount of water for protection to -48ºF? Indicate the rows in the table above on which you based your decision. (Note that finding an exact value may be difficult, so give a range of possible values.)

5. About how much antifreeze should then be added to the system? Explain how you know.

6. Use any method you like to refine your estimate from Question 4. That is, narrow the range of values to find a better estimate for how much water should be drained. If possible, find an exact value.

7. Describe the relationship between the total amount of fluid, the percent concentration of antifreeze, and the amount of pure antifreeze in the cooling system.

Part 3: Word Problems

A mechanic has containers of pure antifreeze solution (which is 100% antifreeze) as well as containers with a 25% antifreeze solution. How many quarts of each should she mix together to get 20 quarts of a 60% antifreeze mixture?

8. Explain how this word problem is related to the activities from Parts 1 and 2. What is already done for you in the word problem that you had to do yourself in the activity?

9. There are two unknown quantities in the problem above. What are they?

10. If the mechanic adds a quart of the 25% antifreeze solution to the mixture, how much pure antifreeze is added? What if she adds two quarts? …*x* quarts?

11. If the mechanic adds a quart of the 100% antifreeze solution to the mixture, how much pure antifreeze is added? What if she adds two quarts? …*y* quarts?

12. The mechanic wants to end up with 20 quarts of a 60% solution. In such a mixture, how many quarts will be pure antifreeze?

13. Use the information from Questions 10-12 to solve the original problem: How many quarts of each solution should she mix together to get 20 quarts of a 60% antifreeze mixture?

14. Explain to a friend how to determine the percent concentration of antifreeze in a cooling system.

15. Jonathan has a leak somewhere in his cooling system. As some of the fluid leaks out, he refills the system with water. Describe what impact this will have on the percent concentration of antifreeze in the system.

16. Brooke wants to make a 52% mixture, but she only has 30% acid solution and a 45% acid solution. Why will she not be able to get a mixture at the desired percent concentration? Explain how you know.

17. Willie read an antifreeze protection chart. For a 10°F level of protection in a 20-quart system, the chart suggested 4 quarts of antifreeze and 16 quarts of water. Because $4 \div 16 = 25\%$, Willie concluded that he needed a 25% percent mixture. Explain what is wrong with his reasoning.