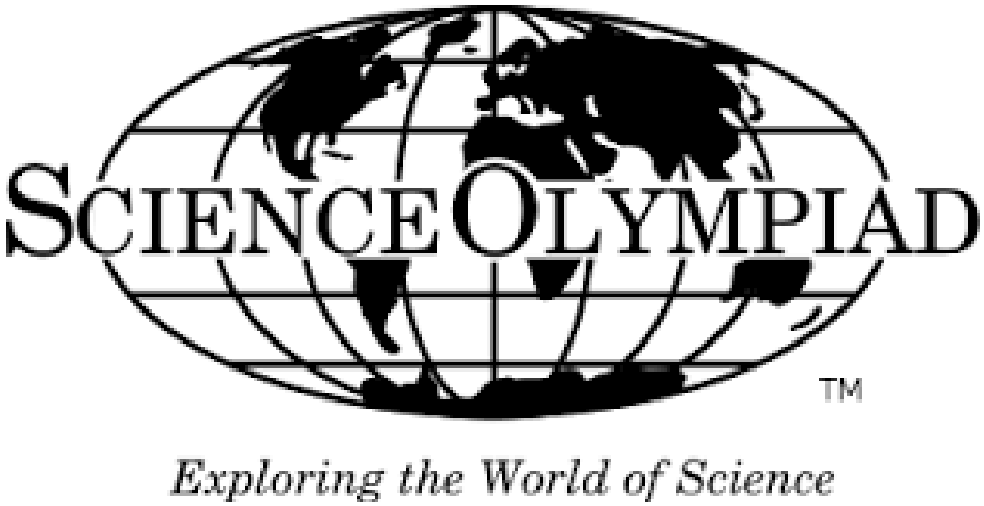
Thermodynamics Exam Division C
Summer Science Olympiad Exchange
Made By: A Brookwood High School Student

TIE BREAKERS (in order)
Question 34
Question 14
Question 23



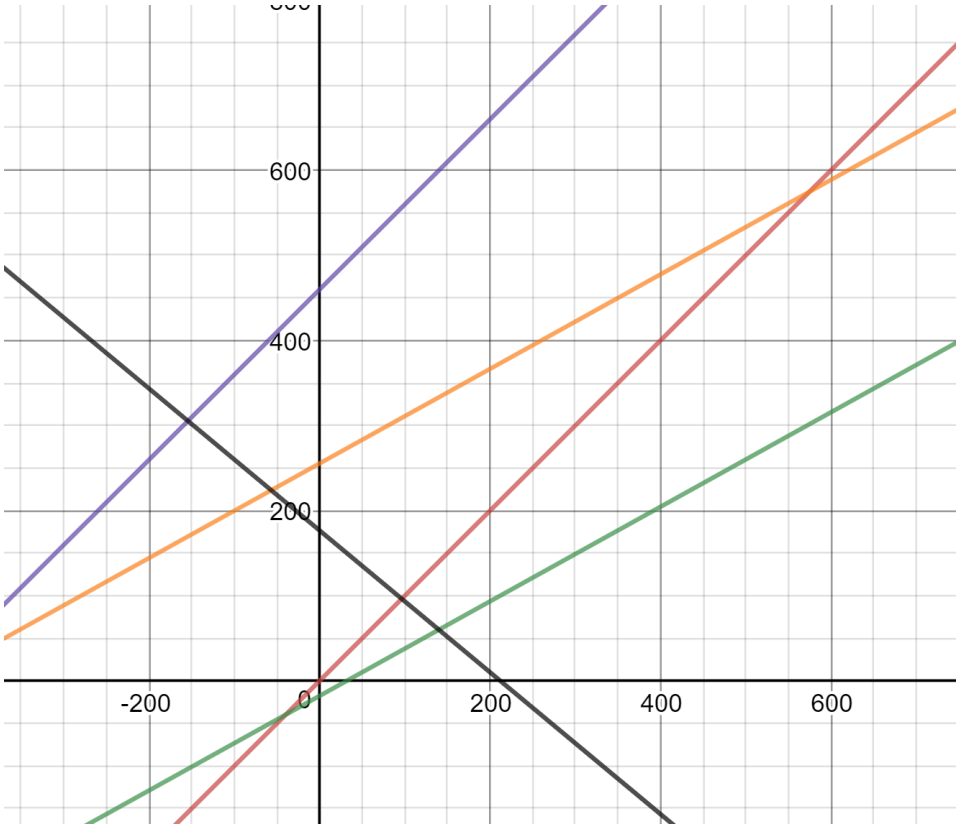
____ / 111 points

1) (1 pt) Which one of the following is not a real temperature scale?
    a) Celcius
    b) Rankine
    c) Newton
    d) Rudolf
    e) Delisle

2) (1 pt) Which temperature is numerically the same in both the °F and Kelvin scales?
    a) 563K
    b) -40°F
    c) 301°C
    d) 574°R
    e) The Fahrenheit and Kelvin scales never match up

3) (1 pt) What units are typically used to describe the ΔH of a chemical reaction?
    a) kJ/mol
    b) eV/mol
    c) J
    d) W
    e) Kcal

4) (1 pt) Which of the following is not equivalent to the others?
    a) 0.822 BTU
    b) 5.94×10^{-4} US therm
    c) 0.867kJ
    d) 5.41×10^{21} eV
    e) 0.207 Kcal



The graph shown above depicts five different temperature scales. Know that the x-axis is in units of degrees Fahrenheit. Assign each line a distinct temperature scale:

5) Red line: _____(1 pt)

6) Green line: _____(1 pt)

7) Orange line:_____(1 pt)

8) Purple line: _____(1 pt)

9) Black line: _____(1 pt)

10) (2 pt) When a freezer (assumed to be turned on) is left open in a room, the temperature of the room will increase. Explain why this happens:

11) (2 pt) Suppose there is both a marble flooring and carpet flooring in a cold room. Thus, the temperature at the surface of both floorings is the same. Yet, it "feels" colder to step on the marble than it does to step on the carpet. Explain why this happens in terms of thermal conductivity.

12) (6 pt) A coffee cup calorimeter is currently holding 74.0g of water at 51.0°F.

a) (3 pt) Then, 68.0g of water at 157.0°F is added to the coffee cup. Assuming that no heat escapes from the calorimeter, AND that the cup itself absorbs no heat, how much heat is being transferred from the hot to cold water? Express your answer in kilojoules.

b) (3 pt) Still assuming that the only energy transfer occurs within the water, what is the final resting temperature in the coffee cup? Express your answer in Celsius.

13) (2 pt) The latent heat of vaporization for water is 40.81 kJ/mol, while its latent heat of fusion is 6.01 kJ/mol. Explain why there is such a big difference between these two values.

14) (10 pt) Draw a phase diagram for water. Use units of Celsius and atm. In addition, label any and all regions/points on the diagram that you think are important.

15) (2 pt) What is the slope of the solid-liquid phase boundary on your phase diagram for water? In addition, explain why it is that way.

16) (1 pt) What is the correct ordering of the steps in the Carnot cycle?
    a) Isothermal gas compression, adiabatic gas expansion, isothermal gas compression, adiabatic gas expansion
    b) Adiabatic gas expansion, adiabatic gas compression, isothermal gas compression, isothermal gas expansion
    c) Adiabatic gas compression, isothermal gas compression, isothermal gas expansion, adiabatic gas expansion
    d) Isothermal gas expansion, adiabatic gas expansion, isothermal gas compression, adiabatic gas compression

17) (3 pt) How many microstates does a sample of water at 50°C have? The entropy of water at 50°C is 75.3 J/k*mol. Boltzmann's constant is $1.381*10^{-23}$ J/K. (Note: you don't need to give a numerical value. An equivalent expression is fine).

For the following reactions, declare whether ΔS is positive or negative, and explain why.

18) $CaCO_{3\,(s)} \rightarrow CaO_{(s)} + CO_{2\,(g)}$ (2 pt)

19) $N_{2\,(g)} + 3H_{2\,(g)} \rightarrow 2NH_{3\,(g)}$ (2 pt)

20) $H_2O_{(l)} \rightarrow H_2O_{(s)}$ (2 pt)

21) $NaCl_{(s)} \rightarrow Na^{+}{}_{(aq)} + Cl^{-}{}_{(aq)}$ (2 pt)

22) (4 pt) 50g of a substance at 225 ℃ is placed in a reservoir of 25.0 ℃. After 15.0 minutes, the temperature of the substance is 200. ℃. If the rate at which this substance loses heat is proportional to the temperature difference between the substance and the environment, calculate the TOTAL time it will take for the temperature of the substance to reach 100. ℃.

23) (6 pt) List 4 of the assumptions of the Caloric Theory of Heat. Name the person who disproved the Caloric Theory of Heat and briefly describe the experiment performed by the scientist and the result that allowed for him to disprove the Caloric Theory of Heat.

24) (5 pt) State the ideal gas law equation. State the name of the scientist who wrote the "corrected" or "real" version of this equation, and show the equation itself. Explain the conceptual meaning behind any constants or variables that show up in this equation but not the ideal gas law equation.

26) (1 pt) An English physicist and brewer, born in Salford, Lancashire. _____ studied the nature of heat, and discovered its relationship to mechanical work.

27) (1 pt) _____ introduced the second law of thermodynamics in 1850.

28) (1 pt) The year 1876, was a seminal point in the development of human thought. During this essential period, chemical engineer _____, published an obscure 300-page paper wherein he formulated one grand equality, the free energy equation.

29) (1 pt) _____ is known for determining the correct value of absolute zero to be -273 C. Prior to this, the lower limit to temperature was assumed to be -267 C.

30) (1 pt) A precursor of the engine was designed by _____who, in 1650, designed and built the world's first vacuum pump and created the world's first ever vacuum known as the Magdeburg hemispheres experiment. He was driven to make a vacuum to disprove Aristotle's long-held supposition that 'Nature abhors a vacuum'.

31) (1 pt) _____ developed a complete theory of the steam engine and indeed of all heat engines. His manuals of engineering science and practice were used for many decades after their publication in the 1850s and 1860s.

32) (8 pt) Draw a basic refrigerator and label the 4 important components. Also label what goes into and leaves each major component (for example, cold low pressure liquid).

33) (8 pt) Describe Maxwell's Demon and explain how it does not in disprove Newton's Second Law of Cooling.

34) (16 pt) Draw the Pressure-Volume diagram AND the Temperature-Entropy diagram of the Otto cycle. Make sure to label corresponding states ON BOTH DIAGRAMS and the different processes.

35) (1 pt) In a calorimeter, the increase in the thermal energy of the water and the decrease in the thermal energy of the sample are _____.

36) (1 pt) The decrease in volume of a material due to a temperature increase is called _____.

37) (1 pt) The transfer of thermal energy with no overall transfer of matter is called _____.

38) (1 pt) The study of the conversion between heat and other forms of energy is called _____.

39) (1 pt) Thermal energy that is not converted into work by a heat engine is called _____.

40) (1 pt) The _____ of a system is the total energy content of the system.

41) (1 pt) As an equation, the first law is _____.

42) (1 pt) An _____ is one in which the pressure on the system remains unchanged throughout the process.

43) (1 pt) Heat that is released or absorbed by a body during a process that occurs without a change in temperature is called _____. A typical example is the change of state of matter.

44) (1 pt) In thermodynamics, the term _____ ("outside heating") describes a process or reaction that releases energy from the system.

45) (1 pt) In the physical sciences, an _____ property (also called a bulk property), is a physical property of a system that does not depend on the system size or the amount of material in the system: it is scale invariant.

46) (1 pt) The first to develop the concept of a thermodynamic system was the French physicist _____whose 1824 “Reflections on the Motive Power of Fire” studied what he called the working substance, e.g., typically a body of water vapor, in steam engines.

47) (1 pt) A mechanically isolated system can exchange no mass or work energy with its environment but may exchange heat energy with its environment. For a simple system, mechanical isolation is equivalent to constant volume and any process which occurs in such a simple system is said to be _____.