

**Thermodynamics – Division B – ANSWER KEY**

School: \_\_\_\_\_ Answer \_\_\_\_\_ V JV1 JV2 JV3 JV4

Student Names: \_\_\_\_\_

Graders:

- /6 1) 13.9 °C, 287 K, 517 °R +1 for each right number, +1 for each correct SigFigs
- /6 2) 80.2 °C +1 for using  $q=mc_p\Delta T$ , +1 for 167.44 J lost/gained +1 for 18.2  $\Delta T$ , +2 for right answer +1 for correct units and sig-figs
- /3 3) 45 J +1 for getting 5 J as the result for mechanical work +1 for getting the right answer, +1 for correct units and sig-figs
- /3 4) A B C D All or nothing on credit
- /3 5) 2800 kJ OR equivalent answer +2 for right answer +1 for correct units and sig-figs
- /6 6) 15.8°C +2 for 16.7 kJ to melt + 3 for right answer +1 for correct units and sig-figs
- /3 7) In order to achieve such a feat, she would need to undergo an infinite amount of \_\_\_\_\_ processes, as stated by the third law of thermodynamics (accept similar response, +1 for statements only consisting of mentioning the Third Law of Thermodynamics)
- /3 8) James Watt All or nothing on credit; full credit for last name only; no credit if incorrect first name
- /6 9) 20 J, 2m<sup>2</sup> +2 for each answer +1 for correct units and sig-figs on each answer
- /4 10) 500 W +3 for right answer +1 for correct units and sig-figs
- /3 11) 2 Liters +1 for finding total pressure to be 2 atm (1 atm applied pressure + 1 atm atmospheric pressure), +1 for use of Boyle's Law to find correct answer (1 atm \* 4 L = 2 atm \* 2L) +1 for correct units and sig-figs
- /3 12) Walther Nernst All or nothing on credit; full credit for last name only; no credit if incorrect first name
- /3 13) 1 Watt; DO NOT ACCEPT "JJ Watt" although that is a clever answer +1 for writing (50/50), +1 for correct answer, +1 for correct units and sig-figs,
- /6 14) A: Radiation B: Convection C: Conduction +2 for each correct response
- /5 15) 1 2 3 4 5 All or nothing on credit
- /4 16) Gas (vapor is acceptable) All or nothing on credit
- /6 17) 90 J +1 for writing First Law ( $U=Q+W$ ), +1 for filling in  $U = 30 + 60$ , +3 for correct answer, +1 for correct units and sig-figs on answer

*Thermodynamics Regionals 2018 B Division Exam*

/3 18) Thomas Newcomen All or nothing on credit; full credit for last name only; no credit if incorrect first name

/6 19) 27 °F (unlikely for summer); +2 for converting 270 K to -3°C; +2 for converting -3°C to 27°F; +1 for correct units, +1 for correct sig-figs; accept the correct numerical answer even if only numerical answer is provided with no explanation

/6 20) Any combination of 3 of the following: James Joule, James Watt, James Forbes, James Thomson, James Maxwell, or any other verifiable response. +2 for each correct name; last names are acceptable since "James" is stated to be the first name in the question

/4 21) Negative All or nothing on credit; "-" symbol acceptable

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Exam instructions: Answer the following questions to the best of your ability. Use correct significant figures unless otherwise stated. Express all answers in SI Units unless otherwise specified. Show all work in the space provided for full credit. Good Luck!

1. You measure a beaker of water to be  $57.0^{\circ}\text{F}$ . What is its temperature in Celsius, Kelvin, and Rankine?

2. You measure a calorimeter of 200. grams of water (specific heat  $4.184 \text{ J}/(\text{g K})$ ) to be at  $60.0^{\circ}\text{C}$  and a piece of aluminum (specific heat  $0.921 \text{ J}/(\text{g K})$ ) to have mass 0.100 kg. After placing the aluminum in the water, you notice the water rise to  $62.0^{\circ}\text{C}$ . What was the initial temperature of the aluminum in  $^{\circ}\text{C}$ ?

3. Use the first law of thermodynamics to answer the following question: A sealed cylinder with a movable piston has its piston compressed into the cylinder .2 m by a 25 N force. The cylinder is then supplied 40 J of heat. What is the total change in internal of the cylinder-piston system?

4. This scientist's first major contribution was a treatise on conservation of energy in 1847. He proposed that light, heat, magnetism, electricity, and mechanical force were all manifestations of the same basic energy that changed forms. He also contributed significantly to our understanding of nerve physiology.

- a. James Watt
- b. Hermann von Helmholtz
- c. Thomas Newcomen
- d. Francis Bacon

5. At Tuffy's Diner, Mr. Wuf consumes a delicious 670 Calorie grilled chicken sandwich. Assuming Mr. Wuf has an idealized body, how much energy will his body release for its use in Joules?

6. You apply 20.0 kJ of heat energy to 50.0 g of ice at 0 °C. What is the final temperature? (Hint: the latent heat of fusion for water is 334 J/g and the specific heat of water is 4.184 J/gK.)

7. Your friend wishes to lower her body temperature to absolute zero. Using your knowledge of thermodynamic laws, **briefly** explain why this is impossible. DO NOT simply state "it defies a law of thermodynamics."

8. This scientist (lived 1736-1819) made significant improvements to the steam engine and invented a device to measure what is now described as "horsepower." A type of steam engine and a unit of measurement is named for him. Which scientist is described?

9. A 100 N force is applied to a 5 square meter piston head. State the pressure experienced by the piston. Next, state the piston head area required to ensure a 50 Pa pressure is experienced by the piston head if the same 100 N force is applied.

10. Your biofuel engine burned 500 dietary Calories. How many Watts of power does your engine output in an hour assuming it has 90% efficiency? Use significant figures.

11. You measure the volume of a gas in a sealed, flexible container to be 4 Liters under atmospheric pressure. You apply 1 atm of pressure to the container without changing the temperature. What is the final volume?

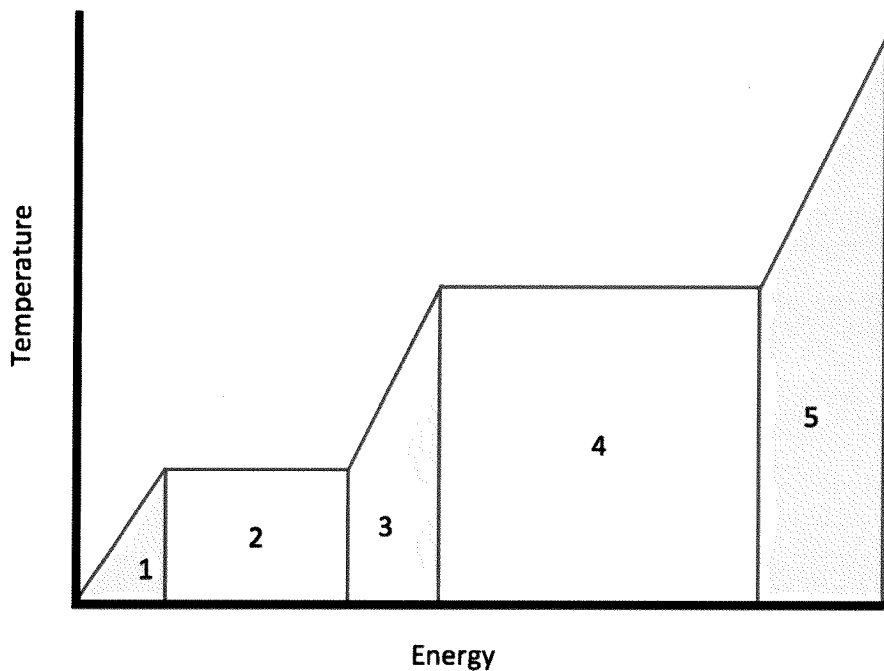
12. Who won the 1920 Nobel Prize in Chemistry (although they were awarded it in 1921) for his/her proof and explanation of the Third Law of Thermodynamics?

13. You measure a heat engine that produces 50 J of energy over a period of 50 s. How much power is produced? Be sure to use correct SI units.

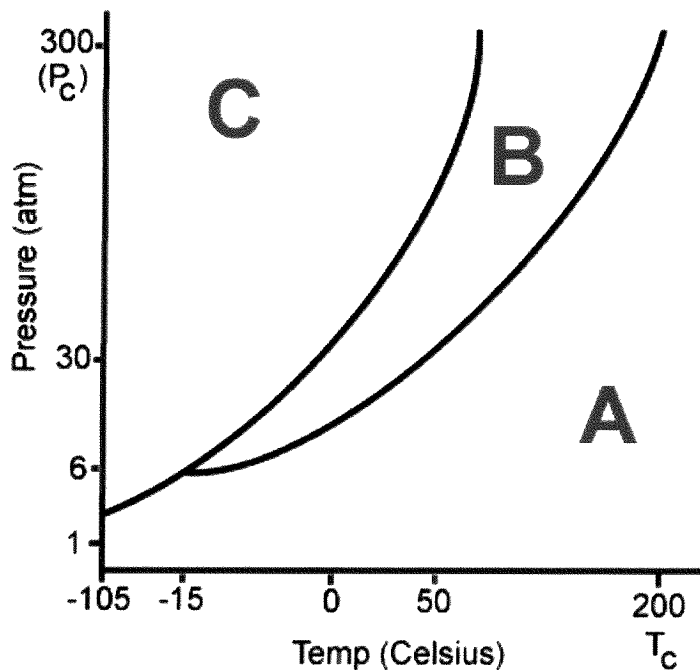
14. Label the different forms of heat transfer shown in the diagram:



15. Which number corresponds to melting in the diagram below?



16. Use the phase diagram below, in what phase would this substance exist at 30 atm of pressure and 170°C?



17. A sealed cylinder has 30 J of work done on it by the system and 60 J of heat added to it. What is the internal energy of the cylinder-system?

18. Who invented the first “true” commercial steam engine using a movable piston? Hint: He called it an “atmospheric engine.”

19. Your friend (who doesn't know quite as much about temperature conversions as you) says that it feels like 270 Kelvin outside. Considering this is summer, convert this temperature to °F to show why this is probably an inaccurate statement.

20. Name three famous thermodynamics pioneers whose given name was James.

21. In the First Law, what sign is given to work done BY a system?