

Topic 3 – Thermal physics

PROBLEM SET

THIS IS A PRACTICE ASSESSMENT. Show formulas, substitutions, answers, and units!

Topic 3.1 – Thermal concepts

The following questions are about internal energy.

1. What are the two forms of internal energy?
2. Suppose a liquid's starting temperature is 20°C and its ending temperature is 35°C. Explain what happens to each form of internal energy.
3. How can you tell if the internal potential energy of a substance has changed?
4. How can you tell if the internal kinetic energy of a substance has changed?

The following questions are about temperature scales.

5. Describe the concept of the absolute zero of temperature and the Kelvin scale of temperature.
6. Convert 273°C to Kelvin.
7. Convert 273 K to Celsius.

The specific heat capacity of a particular block of steel is $500 \text{ J kg}^{-1} \text{ C}^{\circ-1}$. When we add $4 \times 10^6 \text{ J}$ of thermal energy to a block of this steel its temperature increases by 5 °C.



8. What is the mass of the above block?
9. Suppose we now have 200-kg of this same kind of steel. How much heat must be added to raise its temperature by 5 °C?

The specific heat capacity of a particular steel is $460 \text{ J kg}^{-1} \text{ C}^{-1}$. The specific heat of water is $4186 \text{ J kg}^{-1} \text{ C}^{-1}$. The mass of the steel is 550 grams. The mass of the water is 300 grams. The container is extremely light plastic and acts as a good insulator (it doesn't absorb any of the heat). The steel is heated up to 65°C and placed in the water, which is originally at a temperature of 15°C .



10. Which material gains heat and which material loses heat?

11. What is the final temperature of the combination, assuming no heat is lost to the container or the environment?

The following questions are about phase change.

12. Explain in terms of molecular behavior how heat can be added to a substance during phase change, but the temperature remains constant.

13. Draw a T vs. Q graph for a typical substance that shows its five characteristic regions (three regions which show temperature increase and two regions that don't). Label the melting point and the boiling point. Label the freezing point, and the condensation point.



The following questions are about changing the temperature and phase of a 0.50-kg piece of ice. Its starting temperature is -35°C .

14. The ice is warmed up to 0.0°C without melting. How much heat energy in Joules is needed?

15. The ice at 0°C is now warmed up until it all melts, becoming water at 0°C . How much heat energy in Joules is needed?

Substance	$\text{J/kg}\cdot\text{C}^{\circ}$
Water	4186
Steam	2010
Ice	2100

16. The water at 0°C is now warmed up until it reaches a temperature of 100°C but does not begin to boil. How much heat energy in Joules is needed?

Melting Point C°	L_f J/kg	Boiling Point C°	L_v J/kg
0	3.33×10^5	100	22.6×10^5

17. The water at 100°C is now warmed up until it all turns into steam at a temperature of 100°C . How much heat energy in Joules is needed?

18. The steam at 100°C is now warmed up until it reaches a temperature of 135°C . How much heat energy in Joules is needed?

19. 0.50 kilograms of ice at -35°C is warmed up to become steam at 135°C . How much heat energy in Joules is needed?