حل مراجعة الوحدة الرابعة Energy Thermal منهج انسباير Inspire

ID Resources: Topic 4– Thermal Energy

Subtopic 4.1: Temperature, Heat and Thermal Energy

1. In which direction does thermal energy flow spontaneously?

√ A. From hot to cold
B. From cold to hot
C. From light to dark
D. From left to right

2. The measure of average kinetic energy of the particles in the system is the______.

√ A. temperature
B. heat
C. thermal energy
D. specific heat

3. The sum of all the kinetic and potential energies of the particles in the system is the______.

A. temperature
B. heat
√ C. thermal energy
D. specific heat

4. Thermal energy is the ______of the particles in the system.

A. sum of all the kinetic energies
B. sum of all the potential energies
√ C. sum of all the kinetic and potential energies
D. measure of the average kinetic energy

5. Which of the following processes requires no medium to transfer heat?

A. Conduction
B. Convection
√ C. Radiation
D. Evaporation

6. Which thermal exchange process carries thermal energy through boiling water as it heats on top of a stove?

A. Conduction
√ B. Convection
C. Radiation
D. Evaporation

7. Which of the following processes is due to the transfer of energy by collisions between particles?

√ A. Conduction
B. Induction
C. Radiation
D. Fusion

8. Thermal energy is transferred by ____ when objects touch each other.

√ A. conduction
B. convection
C. radiation
D. evaporation

9. What type of heat transfer is responsible to transfer heat from the Sun to the Earth?

A. Conduction

B. Convection

√ C. Radiation

D. Condensation

10. A solid bar is heated at one end. How is thermal energy transferred to the other end of the bar?

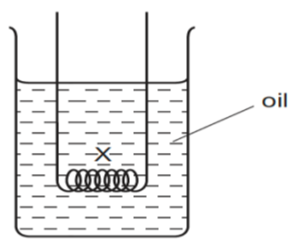
A. Heated molecules move along the bar, carrying energy to the other end

B. Heated molecules move along the bar, giving energy to others along the bar

C. Heated molecules stay completely still, but give energy to other molecules

√ D. Heated molecules vibrate more rapidly and pass energy to other molecules

11. An electrical heater is placed in a beaker of cold oil, as shown. The heater is switched on. What happens to the liquid at X?



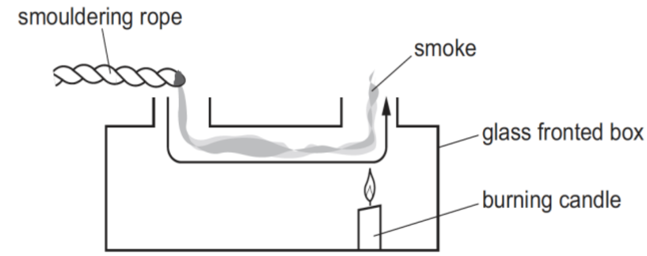
A. It becomes less dense and falls

√ B. It becomes less dense and rises

C. It becomes more dense and falls

D. It becomes more dense and rises

12. When a piece of smoldering rope is held at the opening of the box in the diagram, smoke moves in the direction indicated below.



What is responsible for the movement of the smoke?

√ A. Convection

B. Radiation

C. Conduction

D. Vibration of molecules

13. Specific heat of a substance is the amount of heat required to change the ____ of 1 kg of this substance _____.

√ A.	temperature by 1 K	with no change in its physical state
B.	temperature by 1 K	while changing it from liquid to gas
C.	temperature by 1 K	while changing it from solid to liquid
D.	physical state	from liquid to gas

14. If you wanted to know how much the temperature of a particular piece of material would rise when a known amount of heat was added to it, which of the following quantities would be most helpful to know?

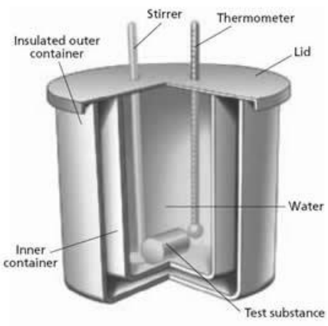
A. initial temperature

√ B. specific heat

C. Latent heat

D. density

15. What is the instrument shown in the figure below?



A. Thermometer

B. Barometer

√ C. Calorimeter

D. Anemometer

16. A hot metal of mass 50.0 g loses 3500 J of heat as its temperature drops by 110°C. What is the specific heat capacity of the metal?

A. 159 $J/kg°C$

B. 510 $J/kg°C$

√ C. 636 $J/kg°C$

D. 770 $J/kg°C$

17. You have equal masses of four materials listed in the table below. All are at the same initial temperature. If you place them in a warmer room, which of the material's temperature will increase most rapidly?

Material	**Specific heat capacity (J/KgK)**
Iron	450
Aluminum	897
Lead	130
Zinc	388

A. Iron

B. Aluminum

√ C. Lead

D. Zinc

18. How much heat is required to raise the temperature of a 225 g lead ball from 15.0°C to 25.0°C? The specific heat of lead is 128 J/kgK.

A. 725 J

B. 576 J

C. 145 J

√ D. 288 J

19. A 100 g piece of glass at a temperature of 70.0°C is immersed completely in 100 g of water initially at a temperature of 16.0°C. What is the final equilibrium temperature of the system?
Consider:
$Specific\ heat\ capacity\ of\ glass = 840\ J/kg.K$
$Specific\ heat\ capacity\ of\ water = 4180\ J/kg.K$

A. 21^0C

√ B. 25^0C

C. 40^0C

D. 55^0C

20. A hot copper cylinder is immersed in an unknown liquid and allowed to reach thermal equilibrium. The masses and temperatures of each are given below. What is the specific heat capacity of the liquid?

	Unknown liquid	**Copper**
Mass (g)	75	70.0
Initial Temperature $(^{\circ}C)$	21.5	85.5
Final Temperature $(^{\circ}C)$	33.5	33.5
Specific heat capacity $(J/kg \cdot C)$	?	385

A. $492\ J/kg \cdot C$

B. $642\ J/kg \cdot C$

C. $712\ J/kg \cdot C$

√ D. $1560\ J/kg \cdot C$

Free Response:

1. How much thermal energy is required to raise the temperature of a 0.75 kg piece of copper pipe by 15°C**?** Specific heat capacity of copper is 387 $J/kg°C$.

$Q = mc\Delta T$

$Q = (0.75\ kg)(387\ J/kg°C)(15\ °C)$

$Q = 4400\ J$

2. How much thermal energy must be removed from a 0.21 kg chunk of ice to lower its temperature by 7.5°C? Specific heat capacity of ice is 2090 $J/kg°C$.

$Q = mc\Delta T$

$Q = (0.21\ kg)(2090\ J/kg°C)(-7.5\ °C)$

$Q = -3300\ J$

3. Suppose 79.3 J of thermal energy is added to a 111 g of aluminum at 22.5 $°C$. What is the final temperature of the aluminum if its specific heat capacity is 900 $J/kg°C$

$$\Delta T = \frac{Q}{mc} = \frac{79.3\ J}{(0.111\ kg)(900\ J/kg°C)} = 0.79°C$$

$T_f = \Delta T + T_i = (22.5 + 0.79)°C = 23.3°C$

4. The change in temperature of a substance when heated, depends on its specific heat capacity.

a. If the specific heat capacity of lead is 120 J/kgK, what is the heat energy required to raise the temperature of 0.50 kg of a lead ball from 25°C to 45°C?

$Q = mc\Delta T$

$Q = (0.50\ kg)(120\ J/kg°C)(45\ °C - 25\ °C) = 1.2 \times 10^3\ J$

b. The 0.50 kg lead ball at 45°C is now dropped into a calorimeter with water at 20°C. If the final temperature of the ball-water system is 25°C, what is the mass of the water?

$Q_{cold} = -Q_{hot}$

$(mc\Delta T)_{cold} = -(mc\Delta T)_{hot}$

$(m)(4.0 \times 10^3\ J/kgK)(25 - 20)°C = -(0.50\ kg)(120\ J/kgK)(25 - 45)°C$

$m = 6.0 \times 10^{-2}\ kg$

5. A 235 g lead ball at a temperature of 84.2 $°C$ is placed in a light calorimeter containing 177 g of water at 21.5 $°C$. Find the equilibrium temperature of the system.

Specific heat capacity of lead = 128 $J/kg°C$

Specific heat capacity of water = 4186 $J/kg°C$

$Q_{cold} = -Q_{hot}$

$(mc\Delta T)_{cold} = -(mc\Delta T)_{hot}$

$(0.177\ kg)(4186\ J/kg°C)(T_f - 21.5°C) = -(0.235\ kg)(128\ J/kg°C)(T_f - 84.2°C)$

$741(T_f - 21.5°C) = -30.1(T_f - 84.2°C)$

$741T_f + 30.1\ T_f = 15931.5 + 2534.4$

$$T_f = \frac{18465.9}{771.1} = 23.9°C$$

6. Suppose 54 g of water at 35°C is poured into a 65 g aluminum cup with an initial temperature of 11°C. Find the final temperature of the system, assuming no heat is exchanged with the surroundings.

Applying energy conservation:

$$Q_W + Q_a = m_W C_W (T - T_W) + m_a C_a (T - T_a) = 0$$

$$T = \frac{m_a C_a T_a + m_W C_W T_W}{m_a C_a + m_W C_W}$$

$$T = \frac{(0.065 \times 900 \times 11) + (0.054 \times 4186 \times 35)}{(0.065 \times 900) + (0.054 \times 4186)}$$

$$T = 30°\text{C}$$

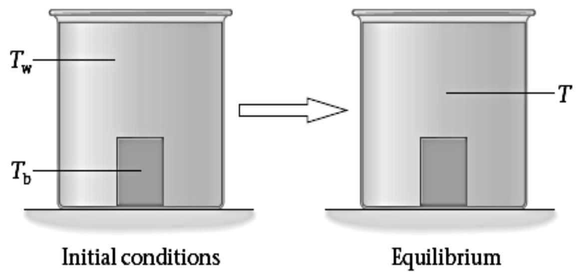
8. A 0.50 kg block of metal with an initial temperature of 54.5 $°C$ is dropped into a container holding 1.1 kg of water at 20.0 $°C$. If the final temperature of the block–water system is 21.4 $°C$, what is the specific heat of the metal block? Assume the container can be ignored, and that no heat is exchanged with the surroundings.

$$Q_{Water} + Q_{block} = m_W C_W (T - T_W) + m_b C_b (T - T_b) = 0$$

$$C_b = \frac{m_W C_W (T - T_W)}{m_b (T_b - T)}$$

$$C_b = \frac{(1.1)(4186)(21.4 - 20.0)}{0.50(54.5 - 21.4)}$$

$$C_b = 390\ J/kgK$$



9. In an insulated container, 0.750 kg of water at 15.0°C, 0.250 kg of Copper at 25.0°C, and 1.20 kg of an unknown metal at 75.0°C are mixed together. The temperature of the system when it reaches thermal equilibrium is 34.0°C.

a. Calculate the heat gained by water.

$$Q_{water} = m.C.\Delta T = 0.750 \times 4186 \times (34.0 - 15.0) = 5.97 \times 10^4\ J$$

b. Calculate the heat gained by copper.

$$Q_{Copper} = m.C.\Delta T = 0.250 \times 387 \times (34.0 - 25.0) = 8.71 \times 10^2\ J$$

c. Calculate the heat lost by the unknown metal in terms of its specific heat.

$$Q_{metal} = m.C.\Delta T = 1.2 \times C \times (34 - 75) = -49.2\ C$$

d. Calculate the specific heat of the unknown metal.

$$Q_{water} + Q_{Copper} + Q_{metal} = 0$$

$$(5.97 \times 10^4) + (8.71 \times 10^2) - (49.2\ C) = 0$$

$$C = 1.23 \times 10^3\ J/kg°C$$

10. In an insulated container, a combination of 1.35 kg of water at 12.0°C, 0.340 kg of copper at 32.0°C, and 1.10 kg of lead at 63.0°C is mixed together. At equilibrium, the system reaches a temperature T.

a. Calculate the heat exchanged by the water during the process in terms of T.
$Q_{water} = m.C.\Delta T = 1.35 \times 4186 \times (T - 12) = 5650T - 67800$

b. Calculate the heat exchanged by the Copper during the process in terms of T.
$Q_{Copper} = m.C.\Delta T = 0.34 \times 387 \times (T - 32) = 132T - 4210$

c. Calculate the heat exchanged by lead in terms of T.
$Q_{Lead} = m.C.\Delta T = 1.1 \times 128 \times (T - 63) = 141T - 8870$

d. Calculate the final temperature T of the system.

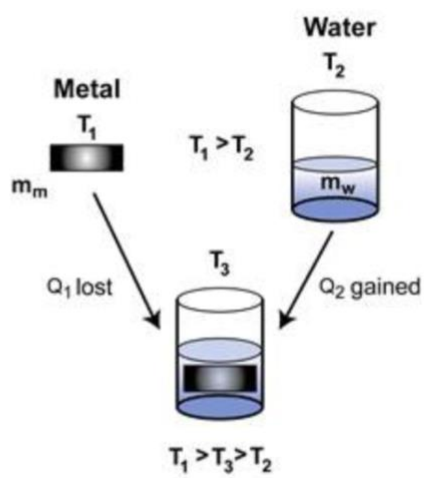
$Q_{water} + Q_{Copper} + Q_{Lead} = 0$

$5650T - 67800 + 132T - 4210 + 141T - 8870 = 0$

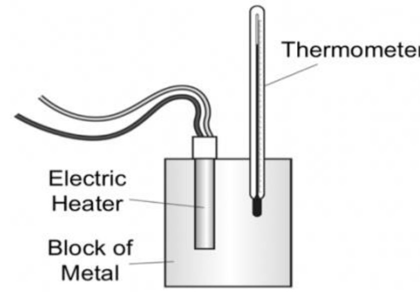
$T = 13.7°C$

11. Describe an experiment to find the specific heat capacity of a metal block.

- Place a known mass of water in a calorimeter whose mass is negligible and measure its temperature.
- Measure the mass of the metal block, and then heat it to a convenient temperature higher than that of the water.
- Drop the warm metal block into the cool water and wait for the system to reach equilibrium.
- Measure the final temperature of the water, which is the same as that of the block.
- Use the equation $Q_{block} + Q_{water} = 0$ to calculate the specific heat capacity of the metal block.



12. The figure below shows the apparatus used to measure the specific heat capacity of a metal. The electric heater is switched on and supplies 17 000 J of thermal energy (heat) to the block of metal. The temperature of the metal rises from 16 °C to 38 °C. The mass of the block of metal is 850 g. No energy is lost from the metal.



a. Calculate the specific heat capacity of the metal.

$$Q = mc\Delta T$$

$$c = \frac{Q}{m\Delta T}$$

$$c = \frac{17000\ J}{(0.850\ kg)(38 - 16°\text{C})} = 909\ J/kg°\text{C}$$

b. Explain how thermal energy is conducted through the metal.

Thermal energy is conducted through the metal by the process of conduction, where the energy is transferred between the molecules by vibrations and collisions.

c. State how you will prevent heat losses from the solid block to the surroundings.

The block can be fully insulated from the surrounding by wrapping it loosely with cotton wool.

13. Four materials of differing masses are heated by different amounts and experience different changes in temperature, as shown below. Find the specific heat capacities of each of the materials and rank the materials in order of increasing specific heat capacity. Indicate ties where appropriate.

Material	**A**	**B**	**C**	**D**
Heat	Q	$2Q$	$3Q$	$4Q$
Mass	m	$3m$	$3m$	$4m$
Temperature Change	ΔT	$3\Delta T$	ΔT	$2\Delta T$

c_A	c_B	c_C	c_D
$c_A = \frac{Q}{m\Delta T}$	$c_A = \frac{2Q}{(3m)(3\Delta T)} = \frac{Q}{3m\Delta T}$	$c_A = \frac{3Q}{(3m)(\Delta T)} = \frac{Q}{m\Delta T}$	$c_A = \frac{4Q}{(4m)(2\Delta T)} = \frac{Q}{2m\Delta T}$
Ranking: $B < D < A = C$			

14. Compare and contrast between conduction, convection and radiation with examples.

	Conduction	Convection	Radiation
Description	• Transfers thermal energy by collisions between particles • Requires a medium to transfer energy • Occurs in solids	• Transfers thermal energy by physical movement of matter • Requires a medium to transfer energy • Occurs in liquids and gases	• Transfers thermal energy through electromagnetic waves • Does not require a medium to transfer energy • Occurs at a distance and with or without matter
Examples	• The bottom of a metal pan gets hot • Touching a stove and being burned • Ice cooling your hand	• Water on the top of a boiling pot gets hot • Hot air rising, cooling and falling • A radiator emitting warm air at the top and drawing in cool air at the bottom	• Heat from a campfire reaches you • Heat from the Sun warming your face • Heat from a lightbulb

15. For each of the situations in the table below, state the process by which heat is transferred.

Getting burnt by touching a hot stove	Conduction
Hot air rising, cooling and falling	Convection
Heat from a campfire when you are seated beside it	Radiation
Ice cooling down your hand	Conduction
Heat from the Sun warming your face	Radiation
Boiling water by thrusting a red-hot piece of iron into it	Conduction and convection
A slice of bread placed under a red-hot electric grill to make toast	Radiation
Heating a tin can of water using a Bunsen burner	Conduction, convection and radiation

Subtopic 4.2: Changes of State and Thermodynamics

1. Thermal energy needed to boil a liquid is the heat of ______.

A. condensation
B. fusion
✓ C. vaporization
D. specific

2. The average kinetic energy of ice particles _____ as ice melts.

A. decreases
B. increases
C. reduces to zero
✓ D. remains constant

3. Ice is added to a glass of juice. The temperature of the juice ______ and the temperature of the ice cubes __________while they are melting.

A.	decreases	increases
B.	decreases	decreases
✓ C.	decreases	stays constant
D.	stays constant	increases
E.	stays constant	stays constant

4. The heat energy required to change 1 kg of a substance from a solid to a liquid state at the same temperature is called ______.

A. specific heat capacity
B. specific latent heat of vaporization
C. sensible heat
✓ D. specific latent heat of fusion

5. Which of the following always accompanies the formation of water from ice?

✓ A. An absorption of thermal energy by ice
B. An increase in temperature
C. A decrease in temperature
D. A removal of thermal energy from ice

6. When a solid melts it _____.

A. gains heat and its temperature decreases
B. gains heat and its temperature increases
C. loses heat and its temperature decreases
✓ D. gains heat and its temperature does not change

7. When a gas condenses it _____ heat and its temperature _____.

A. gains heat, temperature decreases
B. gains heat, temperature increases
C. loses heat, temperature decreases
✓ D. loses heat, temperature doesn't change

8. What is the thermal energy removed to convert 0.5 kg of water at $0°C$ to ice at $0°C$?

A. $0\ J$
✓ B. $1.5 \times 10^5\ J$
C. $3.0 \times 10^5\ J$
D. $6.0 \times 10^5\ J$

9. Ice is added to a glass of juice. The temperature of the juice ______ and the temperature of the ice cubes __________while they are melting.

A.	decreases	increases
B.	decreases	decreases
✓ C.	decreases	stays constant
D.	stays constant	increases

10. A 45.0 kg sample of ice is at 0.00° C. How much heat is needed to melt it? For water L_F = 334,000 J/kg and L_V = 2.256 x10^6 J/kg.

√ A. 1.50 x 10^4 kJ

B. 4.10 x 10^6 kJ

C. 0.00 kJ

D. 1.02 x 10^5 kJ

11. A 50 g of an unknown substance at its melting point absorbs 8000 J of heat to melt completely. What is the latent heat of fusion of the substance?

A. 160 J

B. 400 J

C. 40000 J

√ D. 160000 J

12. The table below shows two substances at their respective melting points. Which of the substances would melt completely when 300 J of heat is added to each of them?

	Mass	**Latent Heat of fusion**
Substance A	20 g	$1.2 \times 10^4 J/kg$
Substance B	30 g	$9.7 \times 10^3 \; J/kg$

A. A only

B. B only

√ C. Both A and B

D. Neither A nor B

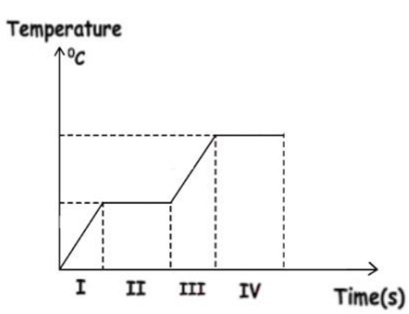
13. Consider the following temperature-time graph when a solid is heated. Which part of the graph involves latent heat of vaporization?

A. Part I

B. Part II

C. Part III

√ D. Part IV



14. Consider the temperature-heat graph below. If L_F and L_V are the latent heat of fusion and vaporization respectively, what is the ratio L_v/L_F?

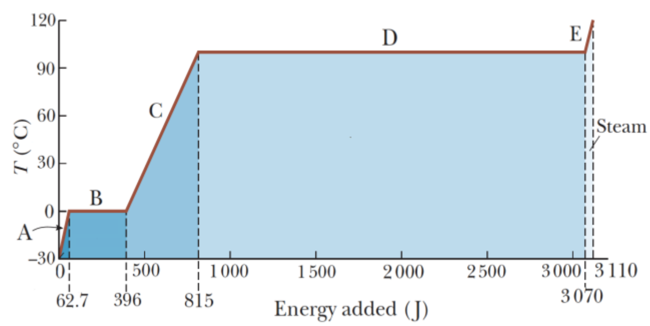
A. 0.50

B. 0.70

C. 1.0

√ D. 1.3

15. 1.00 g of ice at −30.0°C is heated and converts to steam at 120.0°C. The figure below shows how the temperature changes with the heat added. What is the energy used to raise the temperature of 1.00 g of water from 0°C to 100°C?



A. 62.7 J

B. 333 J

√ C. 419 J

D. 2255 J

16. The first law of thermodynamics is a consequence of ______.

A. gravity

√ B. conservation of energy

C. kinetic molecular theory

D. second law of thermodynamics

17. Which law of thermodynamics states that the change in thermal energy is equal to the heat added to the object minus the work done by the object.

√ A. First

B. Second

C. Third

D. Fourth

18. What accounts for an increase in the temperature of a gas that is kept at constant volume?

√ A. Energy has been added as heat to the gas

B. Energy has been removed as heat from the gas

C. Energy has been removed as work done by the gas

D. Energy has been added as work done on the gas

19. The internal energy of a system increased by 25 J while 100 J of heat was added to it. What is work done by the system?

√ A. 75 J

B. 100 J

C. 125 J

D. 2500 J

20. In a process, 850 J of heat is added to a system and 500 J of work is done by the system on its surroundings. What is the change in internal energy of the system?

√ A. 350 J

B. 500 J

C. 850 J

D. 1350 J

21. Which is the example of a heat engine?

A. solar panels

B. refrigerator

√ C. automobile engine

D. heat pump

22. The energy input to an engine is 4 times greater than the work it performs. What is its efficiency?

A. 20%

√ B. 25%

C. 75%

D. 80%

23. A heat engine receives 900 J of heat and releases 100 J of heat in each cycle. What is the efficiency of the engine?

A. 11%

B. 25%

C. 75%

√ D. 89%

24. Which can remove thermal energy from a colder object and add it to a warmer object?

A. Microwave

B. Oven

√ C. Refrigerator

D. Combustion engine

25. A heat engine will increase its efficiency if it produces _______.

√ A. greater work output for the same heat input

B. lesser work output for the same heat input

C. lesser work output for increased heat input

D. the same work output for increased heat input

Free Response:

1. A beaker is filled with water and placed on a hot-plate to boil. The hot-plate is on top of a balance, which measures the mass of water in the beaker. The liquid boils for a long time. There are bubbles within the boiling water.

a. State what is inside each bubble.
Steam or water vapor

b. The mass of water is measured at two different times, while the water is boiling steadily. Use the below data to calculate the specific latent heat of vaporization of water, if during this time;
- the mass of water in the beaker decreases by 20 g
- the energy supplied to the hot-plate is 52 000 J
- the energy lost from the hot-plate and beaker to the atmosphere is 6000 J

$$l_v = \frac{Q}{m} = \frac{(52000 - 6000\ J)}{0.020\ kg} = 2.3 \times 10^6\ J/kg$$

2. Heat is supplied to convert 1.26 kg of water at $100°C$ to steam at $100°C$? Latent heat of vaporization of water is $2.26 \times 10^6\ J/kg$.

a. What is latent heat, and how does it affect the temperature of a substance?
Latent heat is the thermal energy required to change 1 kilogram of a substance from one phase to another. During the conversion process from one phase to another, the temperature of the system remains constant.

b. Calculate the heat supplied to convert the water into steam.
$Q = ml_v = (1.26\ kg)(2.26 \times 10^6\ J/kg) = 2.8 \times 10^6\ J$

3. How much thermal energy must be removed from 0.96 kg of water at $0°C$ to make ice cubes at $0°C$? Latent heat of fusion of ice is $3.35 \times 10^5\ J/kg$.
$Q = ml_f$
$Q = (0.96\ kg)(3.35 \times 10^5 J/kg) = 3.2 \times 10^5\ J$

4. How much thermal energy must be added to 0.96 kg of water at $100°C$ to make steam at $100°C$? Latent heat of vaporization of water is $2.26 \times 10^6\ J/kg$.
$Q = ml_f$
$Q = (0.96\ kg)(2.26 \times 10^6 J/kg) = 2.2 \times 10^6\ J$

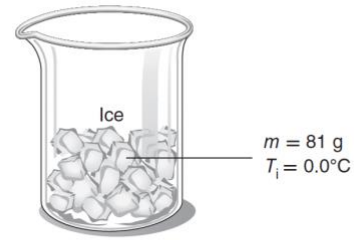
5. How much thermal energy must be added to 1.75 kg of copper to change it from a solid at 1358 K to a liquid at 1358 K? Latent heat of fusion of copper is $2.07 \times 10^5\ J/kg$.
$Q = ml_f$
$Q = (1.75\ kg)(2.07 \times 10^5\ J/kg) = 3.62 \times 10^5\ J$

6. In the figure below, 81 g of ice melts and warms to 10°C. How much thermal energy is absorbed from the surroundings when this occurs?

$Q = (ml_f) + (mc\Delta T)$

$Q = (0.081\ kg \times 3.34 \times 10^5\ J/kg) + (0.081\ kg \times 4180\ J/kg°C \times 10°C)$

$Q = 30\ kJ$



7. How much energy is required to change a 35.0 g ice cube at –5.00 °C into steam at 115°C?

$Q_1 = (mC\Delta T)_{ice} = 0.035 \times 2090 \times (0 + 5) \ = 365.75\ J$

$Q_2 = mL_F = 0.035 \times 3.33 \times 10^5 = 11655\ J$

$Q_3 = (mC\Delta T)_{water} = 0.035 \times 4186 \times (100 - 0) = 14651\ J$

$Q_4 = mL_V = 0.035 \times 2.26 \times 10^6 = 79100\ J$

$Q_5 = (mC\Delta T)_{vapor} = 0.035 \times 2010 \times (115 - 100) = 1055.25\ J$

$Q = \sum Q = 1.07 \times 10^5\ J$

8. In an isolated container, 250 g of ice at -4.0°C is added to 560 g of water at 45°C.

a. Calculate the energy required to melt the 250 g of ice.

$Q_{ice} = (mC\Delta T)_{ice} + m.L_F = 0.25 \times 2090 \times 4 + 0.25 \times 3.33 \times 10^5 = 85340\ J$

b. Calculate the final temperature of the system at thermal equilibrium.

$Q_{ice} + Q_{water} = 0$

$85340 + 0.25 \times 4186 \times (T - 0) + 0.56 \times 4186 \times (T - 45) = 0$

$85340 + 1046.5T + 2344.16T - 105487.2 = 0$

$T = 5.94°C$

9. In an isolated container, 320 g of ice at 0.0°C is added to 640 g of water at 22°C.

a. Calculate the energy required to melt the 320 g of ice.

$Q_{melt} = m.L_F = 0.32 \times 3.33 \times 10^5 = 106560\ J$

b. Calculate the energy lost by the water to reach its freezing point.

$Q_{22°C \to 0°C} = m.C.\Delta T = 0.64 \times 4186 \times (0 - 22) = -58939\ J$

c. How much ice is left when the system reaches equilibrium?

$Q_{water \to 0°C} = m_{melted\ ice} \times L_F$

$m_{melted\ ice} = \dfrac{58939}{3.33 \times 10^5} = 0.18\ kg$

$m_{ice\ left} = 0.32 - 0.18 = 0.14\ kg$

10. Liquids A and B are at their freezing temperatures. Thermal energy is then removed until each solidifies. The amount of heat removed and the mass of each liquid are as follows:

	Heat Removed	**Mass of Liquid**
Liquid A	33,500 J	0.100 kg
Liquid B	166,000 J	0.500 kg

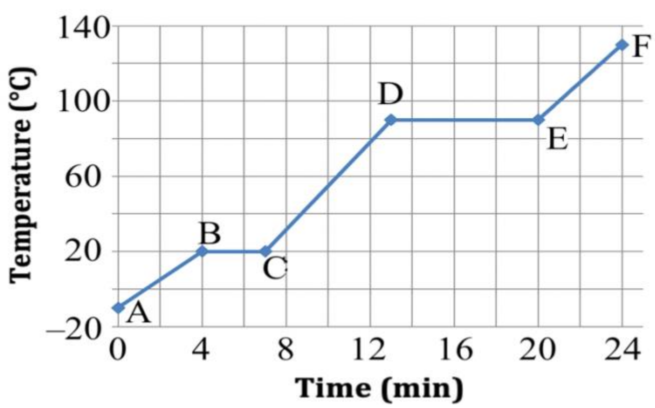
Is the latent heat of fusion of liquid A greater than, less than, or the same as the latent heat of fusion of liquid B?

$$l_{f,A} = \frac{Q_A}{m_A} = \frac{33500\ J}{0.100\ kg} = 3.35 \times 10^5\ J/kg$$

$$l_{f,B} = \frac{Q_B}{m_B} = \frac{166000\ J}{0.500\ kg} = 3.32 \times 10^5\ J/kg$$

By comparing the values of the latent heats we conclude that the latent heat of fusion of liquid A is greater than the latent heat of fusion of liquid B.

11. The graph below shows the heating curve for a substance as it changes from solid to gas.

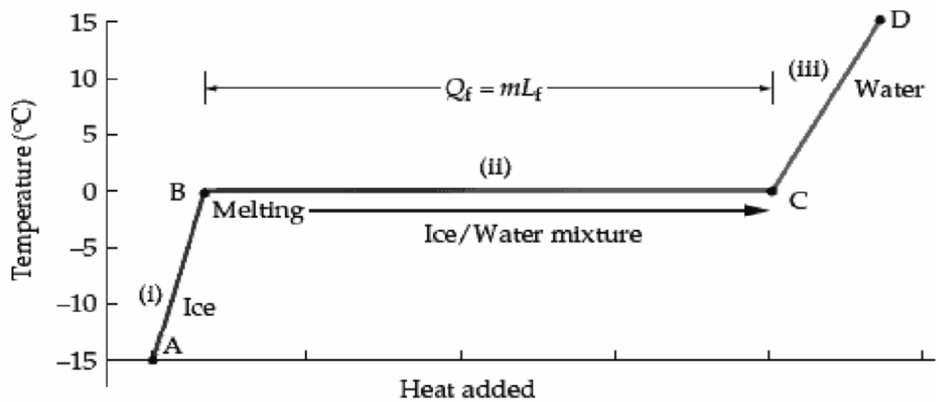


a. Answer the questions in the table below.

What is the melting point of the substance?	20˚C
What is the boiling point of the substance?	90˚C
Which segment represents the substance in only solid state?	AB
Which segment represents the substance in only liquid state?	CD
Which segment represents the substance in only gaseous state?	EF
Which segment represents the substance in a combination of both solid and liquid states?	BC
Which segment represents the substance in a combination of both liquid and gaseous states?	DE

b. Why does the temperature remain constant during a change of state (phase transition)?
During a change of the state of matter, the supplied energy is not used to increase the kinetic energy of the molecules, but to change the binding energies. Therefore, the temperature remains constant

12. The addition of $9.5 \times 10^5\ J$ of thermal energy is required to convert a block of ice at $-15°C$ to water at $15°C$. What was the mass of the block of ice?

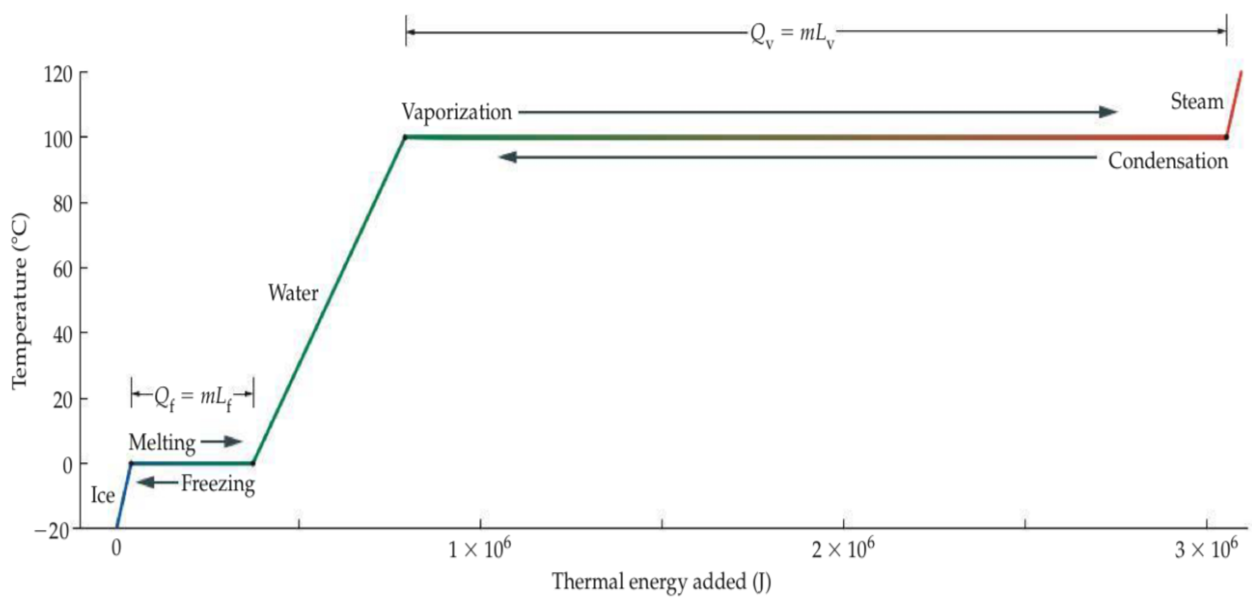


$$Q = Q_i + Q_{ii} + Q_{iii} = mc_{ice}(\Delta T)_1 + ml_f + mc_{water}(\Delta T)_2 \ = m\left[c_{ice}(\Delta T)_1 + l_f + c_{water}(\Delta T)_2\right]$$

$$m = \frac{Q}{c_{ice}(\Delta T)_1 + l_f + c_{water}(\Delta T)_2} = \frac{9.5 \times 10^5\ J}{(2090\ J/kg°C)(15°C) + (3.35 \times 10^4\ J/kg) + (4186\ Jkg°C)(15°C)}$$

$$m = 2.2\ kg$$

13. Suppose the 1.00 kg of water ice in the figure below *begins* melting at time zero. Thermal energy is added to this system at the rate of 12,250 J/s. How much time does it take for the system to reach a temperature of $15°C$?



The time to melt the ice:

$$t_{melt} = \frac{Q_{melt}}{\Delta Q/\Delta t} = \frac{ml_f}{\Delta Q/\Delta t} = \frac{1000\ kg(3.35 \times 10^5\ J/kg)}{12250\ J/s} = 27.3\ s$$

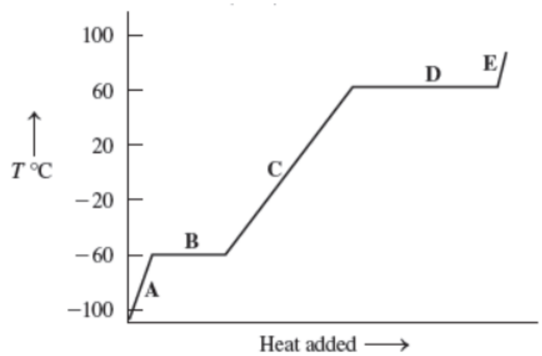
The time to heat the water to 15°C

$$t_{warm} = \frac{mc\Delta T}{\Delta Q/\Delta t} = \frac{1000\ kg(4186\ J/kg°C)(15 - 0°C)}{12250\ J/s} = 5.1\ s$$

The time to melt the ice to the time to heat the water:

$$t_{AC} = t_{AB} + t_{BC} = 27.3\ s + 5.1\ s = 32.4\ s$$

14. The graph below shows the heating curve for 1 kg of a material. Use the graph to complete the table below.



Describe what is happening in each of the regions below

Region	Description
A	The material is in the solid form and its temperature increases with the heat added, until it reaches its melting point of $-60°C$. It absorbs heat equal to the specific heat capacity of the solid to increase the kinetic energy of the molecules
B	The solid is melting at $-60°C$, and so the temperature remains constant. The material is a mix of solid and liquid forms. It absorbs heat equal to the latent heat of fusion of the material to increase the potential energy between the molecules
C	After all the solid has melted, this is the region when the whole material is in the liquid form and its temperature increases until it reaches it boiling point at 60°C. It absorbs heat equal to the specific heat capacity of the liquid to increase the kinetic energy of the molecules
D	At 60°C, the material is boiling and its temperature remains constant until all of the material changes from a liquid to a gas. It absorbs heat equal to the latent heat of vaporization of the material to increase the potential energy between the molecules
E	At E, all the liquid has turned into gas and its temperature increases. It absorbs heat equal to the specific heat capacity of the gas

15. A swimmer does $4.3 \times 10^5\ J$ of work and gives off $1.7 \times 10^5\ J$ of heat during a workout. Determine ΔU, W and Q for the swimmer.
Because the swimmer is doing work on the environment, W is positive, but heat is leaving her body, meaning Q is negative. Use the first law of thermodynamics to find the change in internal energy.

The change in internal energy:
$\Delta U = Q - W$
$\Delta U = -1.7 \times 10^5\ J - 4.3 \times 10^5\ J$
$\Delta U = -6.0 \times 10^5\ J$
The work done is positive:
$W = 4.3 \times 10^5\ J$
The heat emitted is negative:
$Q = -1.7 \times 10^5\ J$

16. How much heat must be added to a gas that does 10 J of work at constant temperature?

$\Delta U = Q - W$

$0 = Q - W \Longrightarrow Q = W$

$Q = 10\ J$

17. During a thermal process, 8.0 J of heat are removed from an ideal gas and the temperature remains constant.

a. What is the change in the internal (thermal) energy of the gas? Justify your answer.
Since there is no change in temperature and hence no change in KE or the change in thermal energy is zero.
$\Longrightarrow\ \Delta U = 0\ J$

b. What is the work done **on the gas** during the process?
$\Delta U = Q + W$
$0 = -8.0 + W$
$W = 8.0\ J$

18. During a cycle, an engine draws 3.50×10^3 J of energy from a hot reservoir and releases 2.25×10^3 J of energy to a cold reservoir.

a. How much work does the engine do in one cycle?
$W = |Q_H| - |Q_C| = 3.50 \times 10^3 - 2.25 \times 10^3 = 1.25 \times 10^3\ J$

b. Calculate the efficiency of the engine.

$$e = \left(1 - \frac{Q_c}{Q_H}\right) \times 100 \ \ \boldsymbol{OR} \ \ e = \left(\frac{W}{Q_H}\right) \times 100$$

$$e = \left(1 - \frac{2.25 \times 10^3}{3.50 \times 10^3}\right) \times 100 = 35.7\%$$

13. During a cycle, a 42% efficient engine draws 5.20×10^3 J of energy from a hot reservoir.

a. How much energy is released by the engine in the cold reservoir in one cycle?

$$e = \left(1 - \frac{Q_c}{Q_H}\right) \times 100$$

$$42 = \left(1 - \frac{Q_c}{5.20 \times 10^3}\right) \times 100$$

$$Q_c = 3016\ J$$

b. How much work does the engine do in one cycle?

$W = |Q_H| - |Q_C| = 5.20 \times 10^3 - 3016 = 2184\ J$

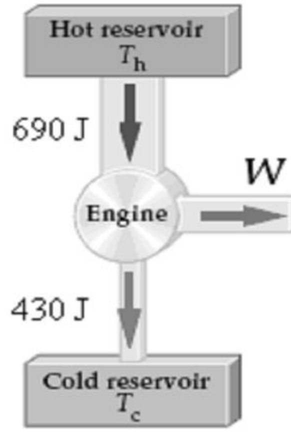
14. An engine receives 690 J of heat from a hot reservoir and gives off 430 J of heat to a cold reservoir.

a. What is the work done by the engine?

$W = Q_h - Q_c$
$W = 690\ J - 430\ J = 260\ J$

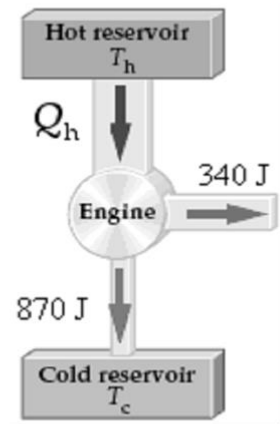
b. What is the efficiency of the engine?

$e = \frac{W}{Q_h}$
$e = \frac{260\ J}{690\ J} = 0.38$



15. What is the efficiency of an engine that exhausts 870 J of heat in the process of doing 340 J of work?

$W = Q_h - Q_c$
$Q = W + Q_h$
$e = \frac{W}{Q_h} = \frac{W}{W + Q_c} = \frac{340\ J}{340\ J + 870\ J} = 0.28$



16. The figures below show two energy diagrams X and Y. Complete the table below to match the diagrams to the corresponding devices.

Device	Energy Diagrams
Heat engine	Diagram X
Heat pump	Diagram Y
Refrigerator	Diagram Y
Combustion Engine	Diagram X