Linear and Volume Expansion Problems

1. Railroad tracks are segmented into short pieces. Why is this a good idea in a place like Saskatchewan?
2. The Eiffel Tower in Paris is 324 meters tall, and is made primarily of iron, which has a coefficient of linear expansion of 12 x 10-6.  The average low in Paris is 1.00°C and the average high is 24°C.  What is average change in height the tower experiences each year? (0.089 m)
3. By how much would you need to heat a 10.0 foot bar of zinc to make it expand by one inch?  The coefficient of linear expansion of zinc is 30 x 10-6 per degree Celsius. (280 °C)
4. A metal bar changes in length by 1.00 meter with a 150 degree Celsius change in temperature.  It’s coefficient of linear expansion is 25 x 10-6 per degree Celsius.  What is the metal bar’s original length? (270 m)
5. An unknown metal alloy is being tested to discover its thermal properties to see if it is suitable for use as a component in an aircraft wing.  The alloy is formed into a bar measuring 1.00 meter in length, and is then heated from its starting temperature of 30 degrees Celsius to a final temperature of 100.0 degrees Celsius.  The length of the heated bar is measured to be exactly 1.002 meters in length.  What is the coefficient of thermal expansion of the alloy to 2 significant figures? (2.6 x 10-5 °C-1)
6. A 200.0 cm copper wire and a 201 cm platinum (9.00 x 10-6 °C-1) wire are both at exactly 0°C. At what temperature will they be of equal length? (629 °C)
7. A circular pyrex (4.0 x 10-6 °C-1)watch glass of 10.0 cm diameter at 21°C is heated to 501°C. What change will be found in the circumference of the glass? (0.060 cm)
8. A 2.00 L aluminum container at 35.0°C heats up to 100.0°C. What is the change in volume the container experiences? (9.8 x 10-3°C)
9. How much does the volume of a 5.0 L copper jug change if it experiences a temperature change of 50.0 °C? (0.013 L)
10. 1.5000 L of antifreeze at 50.000°C cools to -26.000°C. What is the final volume? (1.4877L)
11. How much water will spill from a 5.00 L vat if the temperature increased by 35.0°C? (0.037 L)
12. A concrete (36 x 10-6 °C-1) sidewalk section 8.000 m by 1.000m by 0.100 m at exactly 0°C will expand to what volume at 35°C? (0.801 m3)
13. An air-filled balloon of 15.0 cm radius at 11°C is heated to 121°C. What change in volume occurs? (5.3 X 103 m3)

# Answers

1. Allows room for expansion and contractions

2. 0.089 m 3. 280 ºC 4. 270 m 5. 2.6 x 10-5 °C-1 6. 629 °C 7. 0.060 cm or 6.0 x 10-4 m

8. 9.8 x 10-3°C 9. 0.013 L 10. 1.4877L 11. 0.037 L 12. 0.801 m3 13. 5.3 X 103 m3

Specific Heat Practice Problems

Specific Heat Capacities of Various Materials

|  |  |  |  |
| --- | --- | --- | --- |
| Substance | Specific Heat Capacity (J/kg ºC) | Substance | Specific Heat Capacity (J/kg ºC) |
| Aluminum | 9.0 x 102 | Alcohol (ethyl) | 2.3 x 102 |
| Brass | 3.8 x 102 | Alcohol (methyl) | 2.5 x 102 |
| Copper | 3.9 x 102 | Glycerine | 2.4 x 102 |
| Glass (crown) | 6.7 x 102 | Mercury | 1.4 x 102 |
| Glass (pyrex) | 7.8 x 102 | Nitrogen (liquid) | 1.1 x 102 |
| Gold | 1.3 x 102 | Water (liquid) | 4.2 x 103 |
| Iron | 4.5 x 102 | Water (ice) | 2.1 x 103 |
| Lead | 1.3 x 102 | Water (steam) | 2.0 x 103 |
| Sand | 8.0 x 102 | air | 1.0 x 103 |
| Silver | 2.3 x 102 |  |  |

1. When 3.0 kg of water is cooled from 80.0°C to 10.0°C, how much heat energy is lost?
2. How much heat is needed to raise a 0.30 kg piece of aluminum from 30.°C to 150°C?
3. Calculate the temperature change when:
   1. 10.0 kg of water loses 232 kJ of heat.
   2. 1.96 kJ of heat are added to 500. g of copper.
4. 2.52 x 104 J of heat are added to 2.0 kg of mercury to reach a final temperature of 130°C. What was the initial temperature of the mercury?

# Answers

1. 8.8 x 105 J 2. 3.2 x 104 J 3 a) 5.52 ºC b) 10.1 ºC 4. 40ºC

Heat Exchange Practice Problems

1. 1.0 kg of water at 100.ºC is mixed with 2.0 kg of water at 20.ºC. What is the final temperature of the mixture?
2. 0.100 kg of an unknown metal at 94ºC is placed in 100. grams of water at 10.ºC. The final temperature of the metal and water are 17ºC. What is the heat capacity of the unknown metal?
3. A piece of copper at 90.ºC is added to 0.200 kg of water at 15ºC inside an aluminum calorimeter that has a mass of 0.100 kg. The final temperature of the copper, water, and calorimeter is 25ºC. What is the mass of the copper piece?
4. A 0.100 kg piece of metal is heated to 480ºC and then quickly placed in 0.250 kg of water at 20.ºC which is contained in a 0.200 kg aluminum calorimeter. The final temperature of the water, metal and calorimeter is 36ºC. What is the specific heat capacity of the metal piece?

# Answers

1. T2 = 47ºC 2. c = 3.8 x 102 J/kgºC 3. m = 0.37 kg 4. c = 4.4 x 102 J/kgºC

Latent Heat Practice Problems

# Latent Heat Values

|  |  |  |
| --- | --- | --- |
| **Substance** | **Heat of Fusion (J/kg)** | **Heat of Vaporization (J/kg)** |
| water | 3.3 x 105 | 2.3 x 106 |
| alcohol (ethyl) | 1.4 x 104 | 8.5 x 105 |
| alcohol (methyl) | 6.8 x 104 | 1.1 x 105 |
| gold | 6.3 x 104 | 1.6 x 105 |
| lead | 2.5 x 104 | 8.7 x 105 |
| mercury | 1.2 x 104 | 2.7 x 105 |
| silver | 8.8 x 104 | 2.4 x 106 |
| nitrogen | 2.5 x 104 | 2.0 x 105 |
| oxygen | 1.4 x 104 | 2.1 x 105 |

[Hint: for question 3, remember to use the specific heat capacity value for steam and ice, which is different from liquid water.]

1. How much heat must be added to a 25g ice cube at 0ºC to change it to water at 0ºC?
2. How much heat is lost when 0.10kg of steam at 100.ºC condenses to water at 80. ºC?
3. How much heat is needed to change 0.10kg of ice at –20.ºC. to steam at 110ºC?

**Answers to Problems**

1. 8.3 x 103 J

2. 2.4 x 105 J

3. 3.1 x 105 J

Random Practice Problems

1. A piece of metal with a mass of 1.20 kilograms, specific heat of 390 J/kg · C°, and initial temperature of 87 °C is dropped into an insulated jar that contains 4.5 kg of water at 20.0°C. The metal is removed after 12 seconds, at which time its temperature is 35 °C. Neglect any effects of heat transfer to the air or to the insulated jar. What is the temperature of the liquid after the metal is removed?
2. A steam engine operates on a warm 28.0 °C day. If the ideal efficiency for this engine is 24%, what is the high temperature for the engine?
3. What is the average velocity of the particles of nitrogen at 22.0°C?

**Answers to Problems**

1. heat lost by metal = heat gained by liquid m1c1ΔT1 = m2c2ΔT2

1.2 kg 390 J/kg°C 52 °C = 4.5 kg 4186 J/kg°C ΔT ΔT2 = 1.29 °C

2

Tf = Ti + ΔT = 20.0 °C + 1.3 °C = 21.3 °C

2. e = (TH - TL)/TH

0.24 = (TH - 301 K)/TH

0.24 TH = TH - 301 K

301K = 0.76 TH

TH = 396 K or 123 °C

3. What is the average velocity of the particles of nitrogen at 22.0°C?



vrms =

=

= 511 m/s