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Calorimetry problems with solutions pdf

Calorie meters are designed to minimize energy exchange between the system under investigation and its surroundings. They range from simple coffee cup calorie meters used by chemistry students to advanced bomb calorie meters used to determine the energy content of food. Calorimetry is used to measure the amount of heat transferred to or from a substance. To do this, the heat is changed with a calibrated object (calorie meter). The change in the temperature of the calorimetry measurement part is converted to the amount of heat (since the previous calibration was used to determine its thermal capacity). The measurement of heat transmission by this approach requires the definition of the system (substance or substances undergoing chemical or physical change) and its environment (other parts of the measuring device that either provide heat to the system or absorb heat from the system). Knowledge of the thermal capacity of the environment and careful measurement of the masses of the system and the environment and their temperatures before and after the process allow for the calculation of the transferred heat as described in this Part. A calorie meter is a device used to measure the amount of heat involved in a chemical or physical process. For example, when an exothic reaction occurs in a solution at a caloric meter, the heat produced by the reaction is absorbed into the solution, which raises its temperature. When an endotermic reaction occurs, the required heat is absorbed by the thermal energy of the solution, which lowers its temperature. The temperature change and the specific heat and mass of the solution can then be used to calculate the amount of heat involved in both cases. Coffee-Cup CalorimetersYleischemistry students often use simple calorie meters made of polystylene knob. These easy-to-use coffee cup-calorie meters allow for more heat exchange with their environment, thus producing less accurate energy values. Calorimeter structure of standard volume (or Bomb) This is an image of a typical bomb chambermeter layout. A different type of calorie meter, which acts from a standard volume known in colloquialism as a bomb calorie meter, is used to measure the energy generated by reactions that produce large amounts of heat and gaseous products such as combustion reactions. (The term bomb comes from the observation that these reactions may be strong enough to resemble explosions that would damage other calorie meters.) This type of calorie meter consists of a robust steel container (bomb) that contains the reasses and is itself underwater. The sample is placed in a bomb, which is then filled with oxygen at high pressure. A small electric spark is used to ignite the sample. The energy generated by the reaction is stuck in a steel bomb and surrounding water. Nniiden measured and, together with the known thermal capacity of the calorie meter, the energy generated by the reaction is calculated. Bomb chamber meters require calibration to determine calorimeter thermal capacity and ensure accurate results. Calibration shall be carried out by reacting with a known q, such as a measured amount of benzoic acid ignited by a spark from nickel fuse wire weighed before and after the reaction. The temperature change produced by the known reaction is used to determine the thermal capacity of the calorie meter. Calibration is usually performed each time before the calorie meter is used to collect research data. The 59,7 g piece of metal immersed in boiling water was quickly transferred to 60,0 ml of water initially at 22,0 °C. The final temperature is 28.5 °C. Use this information to determine the specific heat of the metal. Use this result to identify the metal. Solution The first heat transfer, the heat provided by the metal is negative from the heat taken by the water or: $q_{\text{metal}}=-q_{\text{water}}$ In extended format, this is: $c_{\text{metal}} \times m_{\text{metal}} \times \left(T_{\text{f,metal}}-T_{\text{i,metal}} \right) = c_{\text{text water}} \times m_{\text{water}} \times \left(T_{\text{f,water}}-T_{\text{i,water}} \right)$ and water 60.0 ml = 60.0 g; we have: $\left(c_{\text{metal}} \right)\left(59.7\text{ g} \right)\left(28.5^{\text{o}} \text{C} - 100.0^{\text{o}} \text{C} \right) = \left(4.18 \text{ J/g}^{\text{o}} \text{C} \right) \left(60.0\text{ g} \right)\left(28.5^{\text{o}} \text{C} - 22.0^{\text{o}} \text{C} \right)$ Resolve this: $c_{\text {metal}} = \dfrac{- \left(4.184 \text{ J/g}^{\text{o}} \text{C} \right) \left(60.0\text{ g} \right)\left(6.5^{\text{o}} \text{C} \right)}{left\ 59.7 \text{ g} \right)\left(-71.5^{\text{o}} \text{C} \right)} = 0.38 \text{ J/g}^^\text{o}} \text{C} $ Our experimental specific heat is closest to the copper value (0.39 J/g °C), so we recognize the metal as copper. Solutions 1. Phileas Fogg, a character who left the world in 80 days, was very confused by his bath water temperature. It had to be exactly 38.00 C. You're his butler, and one morning, when you checked the temperature in his bath, you'll notice that the temperature is 42.000. You plan to cool 100.0 kg of water to the desired temperature by adding the aluminium duck originally at freezer temperature (-24.0oC). What mass are al-ducks supposed to be? [Lowest specific heat = 0,900 J/(goC); water density =1,00 g/ml]. Let's say no heat is lost in the air. 2. The temperature of a given material (ambient) shall rise to 1,0 0 ° for each 1560 J it receives. 0,1964 g sample of kinon (mole = 108,1 g/mole) was burned, and the temperature of the surrounding material increased from 20,3 oC to 23,5 oC. Find the molar combustion heat of the kinon. 3. 1.55 g of CH4O sample is burned on the calorie meter. If the mold temperature of the CH4O combustio is -725 kJ/ mole and assumes that 2.0 L of water absorbs all the combustio heat, what temperature change did the water get? 4. NaOH neutralizes 0.20 HX moles. The concentrations of base and acid were equal. If the water temperature on the calorie meter went from 19.9 to 24.6C, what was the original HX concentration?
Molar heat of neutralisation = molar heat of -80 kJ/HX 5. In real calorie meters, most of the heat released by the bomb is absorbed by water, but a certain amount is also absorbed by the metal and insulation surrounding the water tank. A certain calorie meter absorbs 24 J/oC. If 50.0 g of 52.7 oC of water is mixed with the original 50.0 g of 22.3 °C water per calorie meter, what is the final temperature of the mixture? Solution #1 -Qwater = QAl mwcwDTw = - mAlcAlDTAl 100 000g(4,19 J/[g C] (38,0 – 42.) 0)= - mAl (0,900 J/[g C])(38,0 – [-24,0]). Solution #2 Qmaterial = 1560 J/oC (23,5-20,3) oC = 49 92 J = 5,0 kJ Note that 1560 J/oC corresponds to mc from Q =mcDT. DH = -Q = -5,0 kJ n = 0,1964g/[108,1 g/mole] = 0,00182 mole DH/n = -5,0 kJ/0,00182 moles = -2,7 X 103 kJ/kinin solution mole #3 n = 1,55 g/[32 g/mole] = 0,0484 moles n[DH/n] = DH 0.0484 moles(-725 kJ/mole)= - 35,1 kJ Q = - DH Q = 35,1 kJ = 35 100 J Q = mc DT 35 100 = 20 00g (4,19 J/[g C]) DT DT = 4,2 C solution #4 n[DH/n] = DH 0,20mole [-80 kJ/mole] = -16 kJ. Q = - DH Q = 16 kJ = 16000 J. Q = mc DT 16000 = m (4,19 J/[g C])(24,6 – 19,9) m = 812 g water. Because the acid concentrations and mole count were equal (moles are equal due to the 1:1 relationship in which HX reacts with NaOH), the volumes used were equal. 812 g = 812 ml created 812/2 = 406 ml acid = 0,406 L content = n/V = 0,20 moles/0,406 L = 0,49 M. Solution #5 Heat wasted by hot water benefits from cold water and calorie meter. -Qhot = Qcold + Qcalor -mc DT = mc DT + 24J/0C DT -50(4.19)(x – 52.7) = 50(4.19)(x –22.3) + 24(x – 22.3) -209.5(x – 5 2.7) = 233.5 (x –22.3) -0.897(x – 52.7) = x – 22.3 -0.897 x + 47.27 = x – 22.3 69.57 = 1.897 x x = 37 oC. PROBLEM \(\PageIndex{1}\) A 500 ml bottle of water was placed in the refrigerator at room temperature and a 2-L water bottle at the same temperature. After 30 minutes, the 500 ml bottle of water had cooled to the temperature of the refrigerator. An hour later, the water 2-L had cooled to the same temperature. When asked a sample of water lost the most heat Student A replied that both bottles lost the same amount of heat because they started at the same temperature and were completed at the same temperature. Student B thought the 2-L water bottle lost more heat because there was more water. A third student believed that the 500ml bottle of water lost more heat because it cooled faster. The fourth student thought it was not possible to tell because we do not know the initial water temperature and the final temperature. Specify which of these answers is correct and describe the error in all other replies. Reply Student A is incorrect because the mass of water in both tanks is not the same. Student C is wrong because the bottle cooled faster due to lower water mass. Student D is flawed because the temperature change doesn't matter as long as it's the same in both bottles. Student B is right: if the temperature change is the same, the one with more mass (2L bottle) had more heat loss. We can prove this by using \(q=c×m×ΔT=c×m×(T_\ce{final}−T_\ce{initial})\) from section 8.1. PROBLEM \(\PageIndex{2}\) How many millilitres of water at 23 °C with a density of 1,00 g/ml must be mixed with 180 ml of coffee at 95 °C to reach the resulting combination temperature of 60 °C? Assume that coffee and water have the same density and the same specific heat (4,184 J/g °C). Answer 170 ml Click here to see the video solution *The part number changed after this video* PROBLEM \(\PageIndex{3}\) How much cup temperature (180 g) is reduced to coffee at 95°C when 45g silver spoons (specific temperature 0.24 J/g°C) are placed in coffee at 25°C and allowed to reach the same temperature? It is assumed that coffee has the same density and specific heat as water. Answer Coffee temperature drops by 1 degree. PROBLEM \(\PageIndex{4}\) A 45 g aluminium spoon (specific heat of 0,88 J/g °C) at 24 °C is set to 180 ml (180 g) of coffee at 85 °C and their temperature is equal. What is the final temperature when the two become equal? It is assumed that coffee has the same specific heat as water. When the student first solved this problem, he received an 88°C response. Explain why this is clearly an incorrect answer. Answer 81.95 °C Answer b This temperature is higher than the starting temperature of the coffee, which is impossible. Click here to see the video of the solution *The modified part number after this video* PROBLEM \(\PageIndex{5}\) Cooling water temperature when it leaves the car's hot engine is 240°F. When it is through the radiator, its temperature is 175 °F. Calculate the amount of heat transferred from the engine to the environment with one gallon of water over a given heat 4.184 J/g °C. Answer \(5.7 \times 10^2\; kJ\) PROBLEM \(\PageIndex{6}\) When 50,0 g 0,200 M NaCl(aq) at 24,1 °C is added to 100,0 g at 0,100 M AgNO3(aq) at 24,1 °C calorimetry, the temperature rises to 25,2 °C, when AgCl(s) is formed. If the specific temperature of the solution and products is 4,20 J/g °C, calculate the estimated amount of heat in joules. Answer 693 J Click here to see a video of the solution PROBLEM \(\PageIndex{7}\) 3.15 g Ba(OH)2•An increase of 8H2O to the 1.52 g NH4SCN solution in 100 g of water per calorie meter caused the temperature to drop by 3.1°C. If the specific temperature of the solution and products is 4,20 J/g °C, calculate the estimated amount of heat absorbed by the reaction, can be represented by the following equation: \[Ba(OH)_2 \cdot 8H_2O_{(s)} + 2NH_4SCN_{(aq)} \rightarrow Ba(SCN)_{2(aq)} + 2NH_{3(aq)} + 10H_2O_{(l)}\] Corresponds to 1.4 kJ PROBLEM \(\PageIndex{8}\) When fructose is 1.0 g, C6H12O6(t), sugar commonly used in fruit, burned in oxygen in the bomb calorie meter, the temperature of the calorie meter rises by 1.58 °C. If the heat capacity of the calorie meter and its contents are 9.90 kJ/°C, what is q for this combustion? Answer 15.64 kJ Click here to see a video of the solution PROBLEM \(\PageIndex{9}\) One way to generate electricity is to burn coal to heat water, which produces steam that controls the power generator. In order to determine the rate at which carbon is fed into the burner in this type of plant, the combustium heat per ton of carbon shall be determined by a bomb carometer. When 1.00 g of carbon is burned in the bomb chamber meter, the temperature rises to 1.48 °C. If the thermal capacity of the calorimetry is 21,6 kJ/°C, the heat produced from the combustion of a ton of carbon (2000 b)) shall be determined. Remember 1 pound = 2.2 kg. Answer 140,659,200 kJ PROBLEM \(\PageIndex{10}\) A teaspoon of carbohydrate sucrose (regular sugar) contains 16 calories (16 kcal). What is the mass of one teaspoon of sucrose if the average number of carbohydrate calories is 4.1 calories per g? Answer 3.90g Click here to see a video of the solution *This issue was renanted after the video* PROBLEM \(\PageIndex{11}\) What is the maximum carbohydrate mass of 6 ounces of diet soda containing less than 1 calorie per can if the average calorie intake of carbohydrates is 4.1 calories/g? Answer 0.24 g PROBLEM \(\PageIndex{12}\) A pint of premium ice cream can contain 1,100 calories. What fat mass, in grams and pounds, should be produced in the body with an extra 1.1 × 103 calories if the average calorie count of fat is 9.1 calories per g? Remember 1 pound = 2.2 kg. Answer 120.87 g 0.055 pounds Click here to see a video of the solution PROBLEM \(\PageIndex{13}\) Serving breakfast cereals contains 3g protein, 18g carbohydrates and g fat. What is the caloric content of this cereal portion if the average calorie intake of fat is 9.1 calories per g, for carbohydrates there are 4.1 calories per g and for protein 4.1 calories/g? Answer 1.4 × 102 Calorie Assistants Do you think one of the answers above is wrong? Just tell us. Here.