**Answer Key Test Review November 8th 2017**

1

**Example of an appropriate and complete solution**

Calculate the heat gained by the water.

*Q*water = *m*•*c*•Δ*T*

= 250 g × 4.19 J/g•°C × (30.7 − 25.0)°C

= 5970.75 J

= 5.971 kJ

Calculate the moles of solid used.

NaCl

Molar mass = 

Moles NaCl = 

Moles NaCl = 

= 0.0799 mol

Calculate the heat of solution in kJ/mol.

∆*H* = 

= 

=

**Answer**: The solid is **NaCl**.

2

**Example of an appropriate and complete solution**

Calculate the quantity of heat absorbed by the water in the calorimeter.

*Q* = *mc*Δ*T*

*Q* = 500g × 4.19J/g/°C × 30.0°C

= 62 850 J (62.85 kJ)

Calculate the Δ*H* per mole of ethanol burned.

Moles of ethanol = 

= 

= 0.05 mol

∆*H* = 

= 

=

If the sample was 100% pure ethanol, then the Δ*H* = -1367 

 = 92%

92% of the heat was released, therefore it is 92% pure.

**Answer**: The sample is an acceptable biofuel.

8

**Example of an appropriate and complete solution**

Δ*H* = 

*n* = 

= 0.0278 mol

3.02 × 103 J/mol = 

Δ*T* = 2.01 × 10−1 °C

**Answer**: The change in the temperature (Δ*T*) of the water is **2.01 × 10−1 °C** or **0.201°C**.

10

Example of an appropriate and complete solution

|  |  |
| --- | --- |
| Using |  |
|  |  |

**Answer**: The specific heat capacity of the piece of brass is **0.623 J/g °C**.

15

Example of an appropriate and complete solution

Heat absorbed by the water

*Q* = *mc*Δ*T*

275 g × 4.19 J/g°C × (94.7 – 16.4)°C = 90 221 J

Molar mass of methanol

12.0 + 4(1.0) + 16.0 = 32.0 g/mol

Mass of methanol burned

642.53 g – 635.68 g = 6.85 g

Number of moles of methanol burned

6.85 g ÷ 32.0 g/mol = 0.214 mol

Δ*H*

-90 221 J ÷ 0.214 mol = -422 000 J/mol or -422 kJ/mol

Answer: The molar heat of combustion (Δ*H*) of methanol is

-422 000 J/mol or -422 kJ/mol.

Note: All extended answers have been worked out using significant figures. However, do not penalize students if they do not consider significant figures.

16

**Example of an appropriate and complete solution**

Mass of water in each cup

125 mL × 1.00 g/mL = 125 g

|  |
| --- |
| Heat lost by metal cube = Heat gained by water |

|  |  |
| --- | --- |
|  | -*Q*(metal) = +*Q*(water) |
| Cube A | -[(115 g) (c) (32°C – 98°C)] = (125 g) (4.19 J/g°C) (32°C – 21°C) |
|  | c = 0.76 J/g°C |

|  |  |
| --- | --- |
| Cube B | -[ (132 g) (c) (35°C – 98°C)] = (125 g) (4.19 J/g°C) (35°C – 21°C) |
|  | c = 0.88 J/g°C |

|  |  |
| --- | --- |
| Cube C | -[ (175 g) (c) (37°C – 98°C)] = (125 g) (4.19 J/g°C) (37°C – 21°C) |
|  | c = 0.79 J/g°C |

**Answer:** The metal cube with the largest heat capacity is **Cube B**.

Note: All extended answers have been worked out using significant figures. However, do not penalize students if they do not consider significant figures.

17

**Example of an appropriate and complete solution**

Δ*H* = 

*m* = 70.0 g

*c* = 4.19 J/g°C

Δ*T* = 29.8°C − 22.4°C

= 7.4°C

mol HCl = 3.00 mol/L × 0.0200 L

= 0.0600 mol

Δ*H* = 

= - 36 000 J/mol or - 36 kJ/mol

**Answer:** The molar heat of neutralization of HCl(aq) is **- 36 000 J/mol or - 36 kJ/mol.**

Note: All extended answers have been worked out using significant figures. However, do not penalize students if they do not consider significant figures.

18

B

19

**Example of an appropriate and complete solution**

1. Moles of NaOH(aq) used

*M* =  or *n* = *MV*

(1.0 mol/L)(50.0 mL/1000mL) = 0.050 moles

2. Heat absorbed

*Q* = *mc*Δ*T*

(70.0 g)(4.19 J/(goC)(29.8-22.3 °C) = 2200 J

3. Since *Q* for the surroundings is positive, *Q* for the system must be negative (or -2200 J)

4. Molar heat of neutralization

Δ*H* = 

 NaOH

-44000 J or -44 kJ/mol NaOH

**Answer:** Δ*H* is **-44 kJ/mol NaOH**.

20

**Example of an appropriate and complete solution**

Δ*T*water = 26 °C − 14 °C = 12 °C

Δ*T*x = 95 °C − 26 °C = 69 °C

*M*w*C*w Δ*T*w = *M*x*C*x Δ*T*x

*C*x = 

= 

= 0.32 J/g °C

**Answer:** The specific heat capacity of the unknown metal is **0.32 J/g °C**.

23

**Example of an appropriate and complete solution**

*Q* = *mc*Δ*T* for the oil

0.92  × 500.0 ~~mL~~ = 460 g

*Q* = 460 g × 2.01  × (300.0°C − 25.0°C)

= 250 000 J or 2.5 × 102 kJ of heat energy to increase the temperature of the oil

 × 2.5 × 102 kJ × 

= 42 g ethanol required

**Answer:** **42 g** of ethanol was burned to heat the oil.

24

**Example of an appropriate and complete solution**

Mass

120.0 mL × 1.0 g/mL = 120.0 g

Specific heat

4.19 J/g°C

Δ*q* = *m* × *c* × Δ*T*

= (120)(4.19)(2.2)

= 1100 J

= -1100 J (or -1.1 kJ)

0.02 L HCl × 1.0  HCl = 0.02 moles HCl

Δ*H* = 

= 

= -55 kJ/mol

**Answer:** The Δ*H* for the reaction is **-55 kJ/mol**.

31

C

32

**Example of an appropriate procedure**

Find the mass of the ice cube in order to find the energy required to melt it.

 = 0.920  at 0°C

The volume of the ice cube = 5.00 cm × 5.00 cm × 5.00 cm = 125 cm3

The mass of the ice = 0.920  × 125 cm3 = 115 g

The heat of fusion of ice = 0.335 

∴ The energy required to melt the ice cube = 0.335  × 115 g = 38.5 kJ

Heat of combustion of ethanol = 29.7 

∴ Mass of ethanol required =  = 1.30 g

**Answer :** The mass of ethanol required to produce the required energy is 1.30 g.

35

B

38

**Example of an appropriate procedure**

Heat lost by metal = Heat gained by water

−Δ*Q*metal = +Δ

−*mc*Δ*T* = +*mc*Δ*T*

− (32.6g)(*T*f − 2.00 × 102°C) = +(1.00 × 102 g)(*T*f − 25.0°C)

−(*T*f − 2.00 × 102°C) = + (*T*f − 25.0°C)

 = 

(2.92 × 103 J + 1.05 × 104 J) = 

(1.34 × 104 J) = 

 = *T*f

30.9°C = *T*f

**Answer : The maximum temperature reached is 30.9°C.**

42

A

46

Heat lost by coffee = Heat gained by milk

-ΔQcoffee = +ΔQmilk

- (m) (c) (ΔT) = + (m) (c) (ΔT)

-(160.0 g) (4.19 J/g•°C) (55.5°C - 80.5°C) = +(m) (4.19 J/g•°C) (55.5°C - 2.0°C)

The specific heat capacity (4.19 J/g•°C) cancels out :

-(160.0 g) (55.5°C - 80.5°C) = +(m) (55.5°C - 2.0°C)

m = 75.0 g

The density can be considered to be 1.00 g/mL.

Therefore, the volume of milk is 75.0 mL

**Answer : The volume of milk is : 75.0 mL.**

47

D

50

**Example of an appropriate solution**

1. Propane consumption

0.050 mole × 5.0 minutes = 0.25 mole

2. C3H8 + 5 O2 → 3 CO2 + 4 H2O + 1662 kJ

1 mole C3H8 = -1662 kJ

0.25 mol = *x*

*x* = -4.2 × 102 kJ

3. *Q*water = *m*•*c*•Δ*T*

*Q*water = −*Q*propane

Δ*T* =  =  = +67 °C

4. Δ*T* = *T*F − *T*i

+67 = *T*F − 25

92 °C = *T*F

**Answer:** The final temperature of the water will be **92 °C**.

**Test Review November 8th 2017**

1

In the laboratory, students are given an unknown crystalline solid and are asked to identify it. They are given a calorimeter filled with 250. mL of distilled water at 25.0 °C and a table of known heats of solution for three substances.

|  |  |
| --- | --- |
| **Substance** | **Heat of solution (kJ/mol)** |
| Lithium chlorate, LiClO3 | -26.59 |
| Potassium hydroxide, KOH | -57.56 |
| Sodium chloride, NaCl | -74.78 |

A student dissolved 4.67 g of the solid in the water in the calorimeter and noted that the resulting temperature was 30.7°C.

Assume no heat is lost to the surroundings.

Which solid was used in the experiment?

2

A biofuel is any fuel that can be derived from a living biological source. One advantage of a biofuel is that it is biodegradable, and thus relatively harmless to the environment, if spilled.

An example of a biofuel is ethanol, C2H5OH. It can be extracted from plants such as corn.

As an experiment, a chemistry student extracted a mixture containing ethanol from corn and decided to test its purity by measuring its heat of combustion.

The student burned the ethanol mixture in a calorimeter and recorded the following data.

|  |  |
| --- | --- |
| Mass of extracted sample of ethanol | 2.30 g |
| Mass of water heated by extracted ethanol | 5.00 × 102 g |
| Initial temperature of the water | 19.0°C |
| Final temperature of the water | 49.0°C |
| *H*combustion of 100% pure ethanol | -1367 kJ/mol |

A fuel that is at least 90% pure is an acceptable biofuel.

Assume that all the heat released is from the combustion of the ethanol.

Is the extracted ethanol mixture an acceptable biofuel?

8

Salicylic acid (C7H6O3) is a key ingredient in many skin-care products for the treatment of acne, psoriasis, calluses, and corns. Salicylic acid is also used as an active ingredient in gels that remove warts. To make the gel, chemists must first dissolve tablets containing salicylic acid in water. The heat of solution (Δ*H*) of salicylic acid is -3.02 kJ/mol.

One tablet containing 3.84 g of salicylic acid is placed in 0.100 L of water.

What is the change in the temperature (Δ*T*) of the water?

10

An 80.5-g piece of brass is heated to a temperature of 95.7°C in a hot water bath. The brass is transferred to a calorimeter containing 105 g of water at a temperature 15.6°C.

The final temperature of the water bath is 23.8°C.

What is the specific heat capacity of the piece of brass?

15

A student performs a simple experiment to obtain an approximate value for the molar heat of combustion of methanol (CH3OH). He adds methanol to a methanol burner and finds its mass. He ignites the methanol and uses the burner to heat a sample of water. After heating the water and allowing the burner to cool, he measures the mass of the burner again. His observations are recorded in the table below:

|  |  |
| --- | --- |
| Mass of water heated | 275 g |
| Mass of the burner and methanol before heating the water | 642.53 g |
| Mass of the burner and methanol after heating the water | 635.68 g |
| Temperature of the water before heating | 16.4°C |
| Temperature of the water after heating | 94.7°C |

The student assumes that all of the heat released by the burning of the methanol was absorbed by the water.

What is the molar heat of combustion (Δ*H*) of methanol?

16

A student finds three metal cubes and wants to determine the specific heat capacity of each cube. First, he finds the mass of each metal cube. He pours 125 mL of distilled water at 21°C into each of three identical Styrofoam cups. Then he heats the three metal cubes to 98°C. He places each metal cube into a different Styrofoam cup and records the resulting temperature of the water and the metal. His results are listed in the table below:

|  |  |  |
| --- | --- | --- |
|  | **Mass** | **Resulting Temperature** |
| Cube A | 115 g | 32°C |
| Cube B | 132 g | 35°C |
| Cube C | 175 g | 37°C |

Which metal cube has the largest specific heat capacity?

(Assume that all of the heat lost by each metal cube was gained by the water.)

Show all your work.

17

When a calorimeter was filled with 20.0 mL of 3.00 mol/L hydrochloric acid, HCl(aq), and 50.0 mL of 1.20 mol/L sodium hydroxide, NaOH(aq), the temperature rose from 22.4°C to 29.8°C.

What was the molar heat of neutralization of HCl(aq)?

(Assume the density and specific heat for all solutions to be equal to that of water.)

Show all your work.

18

You have 250 mL of coffee, whose temperature is 25°C. You add 50.0 mL of water, whose temperature is 95°C.

What will be the final temperature of the coffee?

(Assume that coffee has the same density and specific heat capacity as water.)

|  |  |  |  |
| --- | --- | --- | --- |
| A) | 33°C | C) | 44°C |
| B) | 37°C | D) | 60°C |

19

A calorimeter is filled with 50.0 mL of 1.0 mol/L NaOH(aq) at an initial temperature of 22.3 °C and 20.0 mL of 2.5 mol/L HCl(aq) is added at this same temperature. After the neutralization reaction comes to completion, the final temperature of the resulting solution is found to be 29.8 °C.

Determine the Δ*H* (kJ/mol) for the neutralization for the reaction with respect to the NaOH(aq) solution. (Assume the density and specific heat for all solutions to be equal to that of water)

20

An unknown metal with a mass of 150 g and a temperature of 95 °C is placed into a Styrofoam cup containing 65 g of water at a temperature of 14 °C. When the system reaches equilibrium, the resulting temperature is 26 °C.

What is the specific heat capacity of the unknown metal? (Assume no loss of heat energy to the surroundings.)

23

SternoTM, a solid, portable fuel also known as Canned Heat®, is burned in camp stoves or fondue pots. Its composition is mainly gelled ethanol, C2H5OH.

Cooking oil used in fondue pots has a specific heat capacity of 2.01 J/g°C and a density of 0.92 g/cm3.

At a dinner party, the temperature of 500.0 mL of cooking oil in a fondue pot was increased from 25.0°C to 300.0°C.



Given that ethanol burns as follow:

C2H5OH(s) + 3 O2(g) → 2 CO2(g) + 3 H2O(g) Δ*H* = -278 kJ/mol

How many grams of ethanol were burned in order to heat the oil to 300°C?

24

You were asked to mix 20.0 mL of a 1.0 M HCl solution with 100.0 mL of a 1.0 M NaOH solution. The initial temperature of both solutions was 18.9°C. The temperature of the final solution was 21.1°C.

Assume HCl and NaOH have the same specific heat capacity and density as water.

What is the Δ*H*/mol for the neutralization of HCl?

31

Ammonium nitrate (NH4NO3), one of the active ingredients of commercial ice packs, has a change in enthalpy of +26.2 kJ/mol in the following reaction:

**NH4NO3(s) → NH4+(aq) + NO3−(aq)**

You want to design a practical ice pack with the following characteristics:

• It should contain 100.0 mL of water

• The water’s temperature should drop by 20°C when the pouch containing the NH4NO3 bursts and its contents mix with water.

How much ammonium nitrate should you include in the pouch?

|  |  |  |  |
| --- | --- | --- | --- |
| A) | 0.25 g | C) | 26 g |
| B) | 0.32 g | D) | 310 g |

32

Ethanol is a liquid that combusts relatively easily. In a laboratory investigation, a sample of ethanol was placed into an alcohol burner and ignited. The heat from the combustion of the alcohol was used to melt a cube of ice placed into a beaker as shown below.



Some properties of ethanol and ice are listed below:

Heat of combustion of ethanol = 29.7 kJ/g

Heat of fusion of ice = 0.335 kJ/g

Density of ice = 0.920 g/cm3 at 0°C

Given this information, what *mass of ethanol* is needed to melt a cube of ice that is 5.0 cm on each side?

(Assume 100% of the heat produced from the ethanol is transferred to the ice cube.)

35

When one mole of glacial acetic acid, CH3COOH(l), is mixed with water to make an aqueous solution of acetic acid, 1.6 kJ is released.

When this prepared aqueous acetic acid solution is neutralized with an aqueous solution of sodium hydroxide, NaOH(aq), 50.0 kJ is released.

On the basis of this information, which of the following equations is correct?

|  |  |
| --- | --- |
| A) | CH3COOH(l) + NaOH(aq) + 49.4 kJ → NaCH3COO(aq) + H2O(l) |
| B) | CH3COOH(l) + NaOH(aq) → NaCH3COO(aq) + H2O(l) + 51.6 kJ |
| C) | CH3COOH(l) + NaOH(aq) + 51.6 kJ → NaCH3COO(aq) + H2O(l) |
| D) | CH3COOH(l) + NaOH(aq) → NaCH3COO(aq) + H2O(l) + 49.9 kJ |

38

A piece of metal with a mass of 32.6 grams at a temperature of 2.00 × 102°C is dropped into a calorimeter containing 1.00 × 102 mL of water at 25.0°C.

The specific heat capacity of the metal is 0.448 .

Assuming complete heat transfer between the water and the metal, what will be the maximum temperature of the metal-water system in the calorimeter?

42

Magnesium burns in oxygen according to the following equation:

Mg(s) +  O2(g) → MgO(s) Δ*H* = −6.00 × 102 

If 6.00 g of magnesium metal is burned in an excess of oxygen, what energy will be released during this reaction?

|  |  |
| --- | --- |
| A) | 1.48 × 102 kJ |
| B) | 1.92 × 102 kJ |
| C) | 3.60 × 102 kJ |
| D) | 2.43 × 103 kJ |

46

The *Café Entropy* makes cappuccino.

Cappuccino is a mixture of coffee and milk.

The *Café Entropy* has determined that the best temperature for cappuccino is 55.5°C.

The initial temperature of hot coffee without milk is 80.5°C.

What volume of milk, at 2.0°C, must be added to 160.0 mL of hot coffee in order to obtain the desired temperature of 55.5°C?

(**note:** Assume coffee and milk have the same density and specific heat capacity as water.)

47

When 4.0 g of potassium hydroxide, KOH, is dissolved in 200.0 mL of water in a calorimeter, the temperature increases from 25.0°C to 31.5°C. Calculate the molar heat of solution of the potassium hydroxide.

|  |  |
| --- | --- |
| A) | +5.4 kJ/mol |
| B) | ‑5.4 kJ/mol |
| C) | +76 kJ/mol |
| D) | ‑76 kJ/mol |

50

Having stopped for dinner during your hike in the woods, you pour 1.5 litre of water at 25 ˚C into a kettle. Using a propane burner, you heat this water to make some tea. The burner is used to heat the water and consumes 0.050 moles of propane, C3H8, **every minute** for 5.0 minutes.

What will be the temperature of the water after five minutes of heating?

(Assume a 100% heat transfer from the burner to the water)

Equation of propane combustion:

C3H8(g) + 5 O2(g) → 3 CO2(g) + 4 H2O(g) + 1662 kJ

Show all your work.