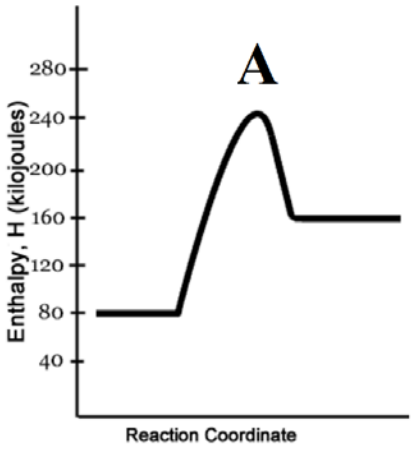
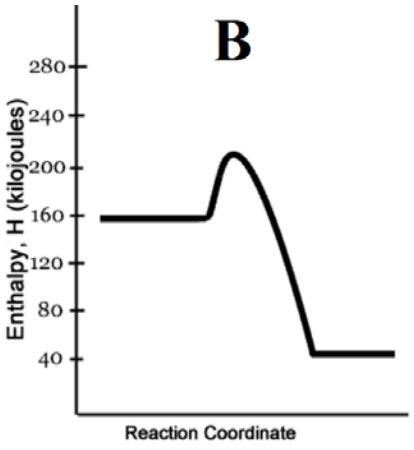
Petroleum 2 Review Questions





1. Above
    a. Label: reactants, products, bond breaking step, bond making step, endothermic step, exothermic step, activation energy, whether reaction as a whole is endothermic or exothermic and whether it would feel hot or cold to the touch
    b. Compute E_A and the overall energy consumed or released
2. Fundamentally, where is the energy stored in hydrocarbons?

3. Where did the energy stored in hydrocarbons come from? (millions of years ago)

4. Where did most of the energy from the candle go? (assume, only about 25% went into the water; hint: same as in cars as you learned in your HW)

5. In your own words define Q, specific heat capacity, ΔT and recite the value for C for water (including correct units)

6. In the candle lab, where did the heat from that raised the water temperature?

7. If 150 J were added to metal cubes of identical mass, which would experience the greater temperature rise: A cube with a large value for C, or a cube with a small value for C?

8. Oregon is north of Illinois, but experience much milder winters. Explain why.

9. Is the bond making step inherently an endothermic or exothermic process?

10. What is the molar heat of combustion and how does it differ from the "heat of combustion"?

11. If a balanced reaction has a coefficient of 3 for the hydrocarbon, then how would you find the energy term for the balanced reaction (assume you have the data table used in class).

Petroleum B - Extra Word Problem Practice - Show ALL WORK for full credit!

Heats of Combustion & Molar Heats of Combustion			
C's	**Hydrocarbon**	**Heat of combustion (kJ/g)**	**Molar heat of combustion (kJ/mol)**
1	Methane	55.6	890
2	Ethane	52.0	1560
3	Propane	50.0	2200
4	Butane	49.3	2859
5	Pentane	48.8	3510
6	Hexane	48.2	4141

1. How many KJ are released from the combustion of 25 g of propane?

2. How many J are released from the combustion of 175 g of C_5H_{12}?

3. How many KJ are released from the combustion of 4.5 moles of C_2H_6?

4. Write a complete balanced equation for the combustion of Ethane

5. Write a complete balanced equation for the combustion of Pentane

6. Write a complete balanced equation for the combustion of C_3H_8?

7. A 312 g metal cube is placed in boiling water. The temperature the boiling water is measured to be 99.5°C. The cube is placed in 100.0 mL of room temperature water initially measured to be 22.8°C. After a few minutes, the water temperature stabilizes at 34.0°C. What is the specific heat capacity the metal based on this data?

8. A lighter is held underneath a pop can. The pop can contains 125 ML of water. After 5 min., the temperature of the pop can has risen from 5.7°C to 41.4°C. How many kilojoules of energy was absorbed by the water in the pop can?

9. A 45.03 g candle is placed beneath a pop can containing 100.0 ML of water. Initially the temperature of the chilled water was 2.6°C. After a while, the temperature of the pop can had risen to 36.0°C. Upon completion of this experiment, the new weight of the candle was found to be 44.64 g. Assuming the wax is composed of a 30 carbon alkane, from this data find the molar heat of combustion for the wax, find
    a. The molar heat of combustion for the wax

    b. The heat of combustion for the wax

Key

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Heats of Combustion & Molar Heats of Combustion			
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1. How many KJ are released from the combustion of 25 g of propane?

$\left(\frac{25\ g\ C_3}{1}\right)\left(\frac{50.0\ KJ}{1\ g\ C_3}\right) = 1300\ KJ$ ← 2 sig Figs

2. How many J are released from the combustion of 175 g of C_5H_{12}?

$\left(\frac{175\ g\ C_5}{1}\right)\left(\frac{48.8\ KJ}{1\ g\ C_5}\right) = 8540\ KJ$

3. How many KJ are released from the combustion of 4.5 moles of C_2H_6?

$\left(\frac{4.5\ mol\ C_2}{1}\right)\left(\frac{1560\ KJ}{mol\ C_2}\right) = 7.0 \times 10^3\ KJ$ ← 2 sig!

4. Write a complete balanced equation for the combustion of Ethane

$2\ C_2H_6 + 7O_2 \rightarrow 4\ CO_2 + 6\ H_2O + 3120\ KJ$

→ $2 \times 1560 = 3120$

5. Write a complete balanced equation for the combustion of Pentane

$C_5H_{12} + 8\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O + 3510\ KJ$

1×3510

6. Write a complete balanced equation for the combustion of C_3H_8?

$C_3H_8 + 5O_2 \rightarrow 3\ CO_2 + 4\ H_2O + 2200\ KJ$

7. A 312 g metal cube is placed in boiling water. The temperature the boiling water is measured to be 99.5°C. The cube is placed in 100.0 mL of room temperature water initially measured to be 22.8°C. After a few minutes, the water temperature stabilizes at 34.0°C. What is the specific heat capacity the metal based on this data?

$\Delta T_m = 99.5 - 34.0 = 61.5^\circ$

$\Delta T_w = 34.0 - 22.8 = 11.2^\circ$

$Q_w = m\ c\ \Delta T$

$= (100.0\ g)\left(4.2\ \frac{J}{g^\circ C}\right)(11.2^\circ C)$

$= 4704\ J$ ← 3 sig

$Q_m = Q_w = 4704\ J$

$Q_m = m_m\ C_m\ \Delta T_m \rightarrow 4704 = 312 \times C_m \times 61.5$

$4704 = 19188\ C_m \rightarrow C_m = \frac{0.245\ J}{g^\circ C}$

8. A lighter is held underneath a pop can. The pop can contains 125 ML of water. After 5 min., the temperature of the pop can has risen from 5.7°C to 41.4°C. How many kilojoules of energy was absorbed by the water in the pop can?

$Q = mc\Delta T$ ← 35.9 ← Not measured ← 35.9 } use 35.9 in final answer

$= (125\,g)\left(\frac{4.2\,J}{g\,°C}\right)(41.4 - 5.7\,°C)$

$= 125(4.2)(35.7) = 18{,}742.5\,J$

$18{,}700\,J = \underline{18.7\,KJ}$

9. A 45.03 g candle is placed beneath a pop can containing 100.0 ML of water. Initially the temperature of the chilled water was 2.6°C. After a while, the temperature of the pop can had risen to 36.0°C. Upon completion of this experiment, the new weight of the candle was found to be 44.64 g. Assuming the wax is composed of a 30 carbon alkane, from this data find the molar heat of combustion for the wax, find

a. The molar heat of combustion for the wax

Plan: 1) find KJ into H_2O
2) find g of wax consumed
3) convert g → mol using molar mass
4) Molar Heat of combust. = KJ/mol

(1) $Q_w = mc\Delta T$ ← 36 − 2.6 °C

$= (100.0\,g)\left(\frac{4.2\,J}{g\,°C}\right)(33.4\,°C)$

$= 14{,}028\,J$

$= 14.028\,KJ$ ← King Henry ← 2 sig ← 3 sig in final answer

(2) $45.03 - 44.64 = .399\,g$

(3) molar mass of $C_{30}H_{62} \rightarrow 30(12.01) + 62(1.01) = 422.92\,g/mol$

$\left(\frac{.399\,g\ wax}{1}\right)\left(\frac{1\,mol\ wax}{422.92\,g\ wax}\right) = .0009222\,mol\ wax$

(4) $MHOC = \frac{14.028\,KJ}{.0009222\,mol} = 15{,}212\,\frac{KJ}{mol} = \boxed{15{,}000\,KJ/mol}$ ← 2 sig figs

b. The heat of combustion for the wax

$HOC = \frac{KJ}{g} = \frac{14.028\,KJ}{.399\,g} = \boxed{36\,\frac{KJ}{g}}$

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1. How many KJ are released from the complete combustion of 67 g of butane?

2. How much energy is released from combusting of 3.4 moles of C_6H_{14}?

3. A Cheeto is burned in a calorimeter containing 150 mL of water. If the water's initial temperature was 5.5°C in the final temperature of the water was 11.8°C, then how much energy was absorbed by the water?

4. An unknown 240 g metal cube is placed in boiling water. The temperature of the boiling water is measured to be 99.7°C. The hot metal cube was removed from the hot water and placed into 85 mL of chilled 2.5°C water. After several minutes the temperature of the water had risen to 14.0°C. What is the specific heat capacity of the metal based on these results?

5. How many KJ are released from the combustion of 4.5 moles of C_2H_6?

6. A candle is combusted over 100.0 mL of water. The initial water temperature is 18.5°C and the final water temperature is 36.1°C. How much energy was absorbed by the water?

7. A 326 g metal cube is at a temperature of 99.0°C. This hot metal cube is placed in 55.0 ML of room temperature water where the room temperature is measured at 22.5°C. After enough time has passed that the water temperature has stabilized at 38.3°C the specific heat capacity of the metal is determined. What is the specific heat capacity the metal including proper units?

8. Write a complete and balanced equation for the combustion of C_4H_{10}.

9. A candle and index card are found to have a mass of 26.74 g. The candle is lit and placed below 98.0 mL of water whose initial temperature is 9.5°C. The combustion continues until the water temperature rises to 44.6°C. The candle and index card are weighed again and found to have a mass of 25.98 g.
    a. How many kilojoules of energy was released by the candle?

    b. What is the heat of combustion for the candle?

10. A 305 g metal cube and 98.6°C water are placed into 205 mL of 5.5°C water. The temperature of the chilled water rises until it reaches a final temperature of 16.8°C. What is the specific heat capacity of the metal?

11. A candle and index card are found to have a joint mass of 31.61 g. The candle is lit beneath a can containing 65.0 mL of 5.8°C water. The combustion process continues until the water temperature reaches 20.0°C. At that point the candle and index card are massed again it is found that their new combined mass is 30.88 g. What is the heat of combustion for the paraffin wax?

12. How much energy is released from the complete combustion of 175 g of pentane?

13. A marshmallow is burned and heats up 58.4 mL of water from an initial temperature of 22.5°C up to a final temperature of 41.3°C.
    a. How much energy was released by the marshmallow into the water?

    b. Where did most of the wasted energy released by the marshmallow go?

    c. How is this similar to what happens in automobiles?

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Heats of Combustion & Molar Heats of Combustion			
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6	Hexane	48.2	4141

1. How many KJ are released from the complete combustion of 67 g of butane?

(2) $67\ g\ C_4 \left| \frac{49.3\ KJ}{1\ g\ C_4} \right. = 3,300\ KJ$

2. How much energy is released from combusting of 3.4 moles of C_6H_{14}?

(2) $3.4\ mol\ C_6 \left| \frac{4141\ KJ}{1\ mol\ C_6} \right. = 14,000\ KJ$

3. A Cheeto is burned in a calorimeter containing 150 mL of water. If the water's initial temperature was 5.5°C in the final temperature of the water was 11.8°C, then how much energy was absorbed by the water?

$Q = ?$
$m = 150$ (2)
$\Delta T = 11.8 - 5.5 = 6.3°C$ (2)

$Q = mc\Delta T$
$= 150(4.184)6.3 = 4.0 \times 10^3\ J$
$(4.0\ KJ)$

4. An unknown 240 g metal cube is placed in boiling water. The temperature of the boiling water is measured to be 99.7°C. The hot metal cube was removed from the hot water and placed into 85 mL of chilled 2.5°C water. After several minutes the temperature of the water had risen to 14.0°C. What is the specific heat capacity of the metal based on these results?

$Q_w = (mc\Delta T)_w$
$= 85(4.184)(14.0 - 2.5)$
$= 4089.86 \leftarrow$ (2) 2 sig figs!
$4,100\ J$

$Q_M = Q_w$
$(mc\Delta T)_M = 4,100\ J$
$240(c)(99.7 - 14.0) = 4,100$
$= 0.20\ J/g/°C$

5. How many KJ are released from the combustion of 4.5 moles of C_2H_6?

(2) $4.5\ mol\ C_2 \left| \frac{1560\ KJ}{1\ mol\ C} \right. = 7.0 \times 10^3\ KJ$

6. A candle is combusted over 100.0 ~~mL~~ mL of water. The initial water temperature is 18.5°C and the final water temperature is 36.1°C. How much energy was absorbed by the water?

(3)
$Q = mc\Delta T$
$= 100.0 \times 4.184(36.1 - 18.5)$
$= 7,360\ J \quad (7.36\ KJ)$

7. A 326 g metal cube is at a temperature of 99.0°C. This hot metal cube is placed in 55.0 ML of room temperature water where the room temperature is measured at 22.5°C. After enough time has passed that the water temperature has stabilized at 38.3°C the specific heat capacity of the metal is determined. What is the specific heat capacity the metal including proper units?

$Q_M = Q_W$

$mC\Delta T = mC\Delta T$ (3)

$326 \times C \times (99.0 - 38.3) = 55.0 \times 4.184 (38.3 - 22.5)$

$19{,}788.2 \times C = 3{,}635.896$

$C_m = 0.184\ J/g/^oC$

8. Write a complete and balanced equation for the combustion of C_4H_{10}.

$2\,C_4H_{10} + 13\,O_2 \rightarrow 10H_2O + 8CO_2 + 5718\ KJ$ ← double 2859 since coeff is 2 for hydrocarbon

9. A candle and index card are found to have a mass of 26.74 g. The candle is lit and placed below 98.0 mL of water whose initial temperature is 9.5°C. The combustion continues until the water temperature rises to 44.6°C. The candle and index card are weighed again and found to have a mass of 25.98 g.

   a. How many kilojoules of energy was released by the candle? (3)

   $Q_m = Q_w = (mC\Delta T)_w = 98.0 \times 4.184 (44.6 - 9.5) = 14{,}400\ J$

   $= 14.4\ KJ$

   b. What is the heat of combustion for the candle? (2)

   $HOC = KJ/g \rightarrow 14.4\ KJ / (26.74 - 25.98) = \frac{14.4}{.76} = 19\ KJ/g$

10. A 305 g metal cube and 98.6°C water are placed into 205 ~~ML~~ mL of 5.5°C water. The temperature of the chilled water rises until it reaches a final temperature of 16.8°C. What is the specific heat capacity of the metal? $Q_m = Q_w$ (3)

$mC\Delta T = mC\Delta T$

$305 \times C \times (98.6 - 16.8) = 205 \times 4.184 \times (16.8 - 5.5)$

$24{,}949\,C = 9692.236$

$C = 0.388\ J/g/^oC$

11. A candle and index card are found to have a joint mass of 31.61 g. The candle is lit beneath a can containing 65.0 mL of 5.8°C water. The combustion process continues until the water temperature reaches 20.0°C. At that point the candle and index card are massed again it is found that their new combined mass is 30.88 g. What is the heat of combustion for the paraffin wax?

$Q_{wax} = Q_{water} = 65.0 \times 4.184 \times 14.2 = 3{,}860\ J = 3.86\ KJ$

$\Delta M_{candle} = 31.61 - 30.88 = .73\ g$ (2)

$HOC = \frac{KJ}{g} = \frac{3.86}{.73} = 5.3\ KJ/g$

12. How much energy is released from the complete combustion of 175 g of pentane? (3)

$175\ g\ C_5 \left| \frac{48.8\ KJ}{1\ g\ C_5} \right. = 8{,}540\ KJ$

13. A marshmallow is burned and heats up 58.4 ~~ML~~ mL of water from an initial temperature of 22.5°C up to a final temperature of 41.3°C.

   a. How much energy was released by the marshmallow into the water?

   $Q = mC\Delta T = 58.4 \times 4.184 \times (41.3 - 22.5) = 4{,}590\ J = 4.59\ KJ$

   b. Where did most of the wasted energy released by the marshmallow go?

   waste heat (heat up air, etc.)

   c. How is this similar to what happens in automobiles? They lose ~75% of their energy to surroundings rather than propulsion