Sample Diploma Problem

Use the following information to answer question 6.

Some Environmental Issues

I	Acid deposition
II	Ozone depletion
III	Particulate emissions
IV	Global climate change

In Alberta, most of the electricity is generated by burning coal.

6. If Albertans switched to more energy-efficient light bulbs, it would lessen the contribution of the environmental issues numbered

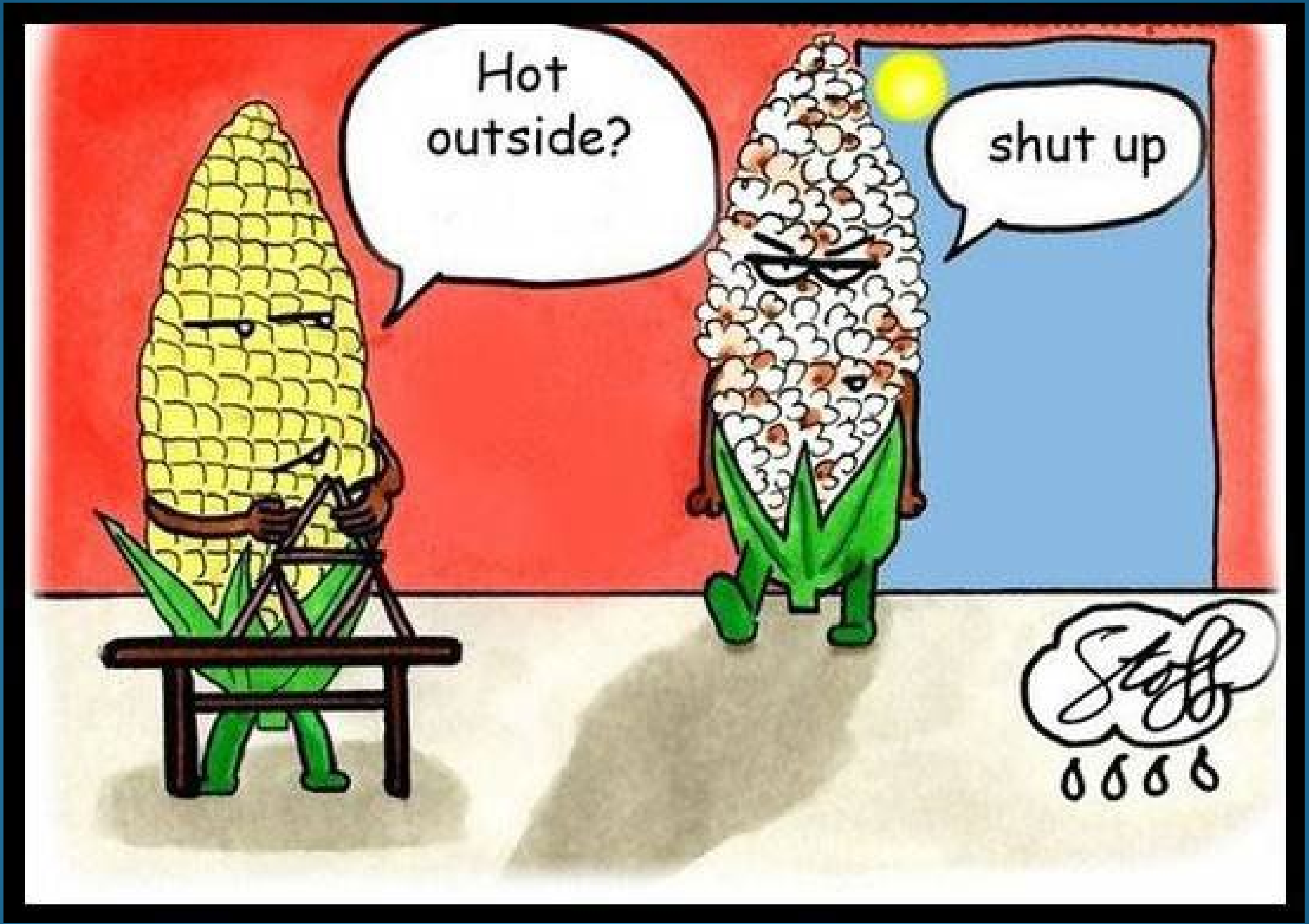
A. I and II only

B. II and III only

C. I, III, and IV only

D. I, II, III, and IV

Hess's Law



Curriculum

- explain how Hess's Law, $\Delta H°= \Sigma\Delta f\ H°$ (products) – $\Sigma\Delta f\ H°$ (reactants), leads to prediction of heats of combustion

Questions

- When you burn a piece of firewood, where does all that heat come from?

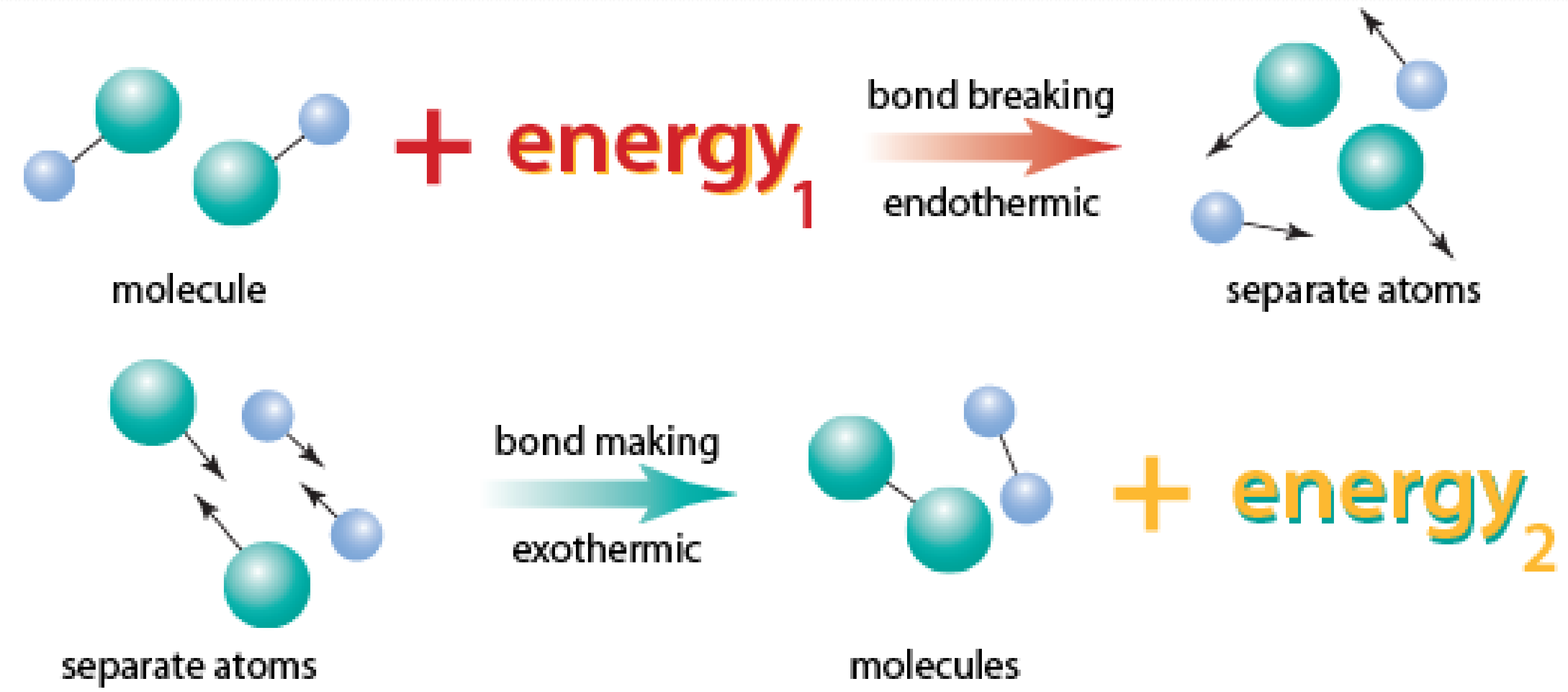
- Originally from the sun, then the bonds break, releasing the energy

Average Bond Energies

Average Bond Energies
kJ/mol

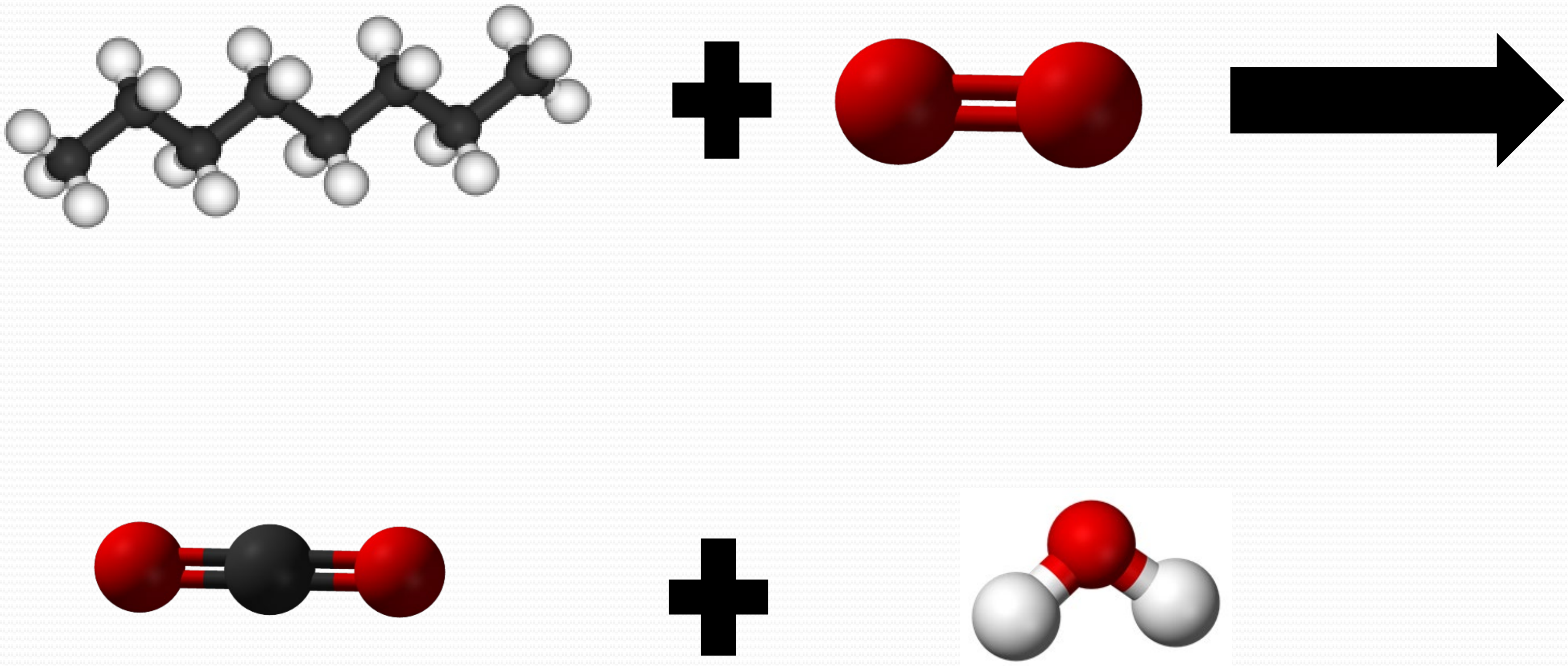
C-C	347	C-S	255	N=N	418
C=C	619	C=S	477	N≡N	941
C≡C	812	H-H	436	N-O	176
C-H	414	H-F	569	O-O	138
C-N	305	H-*Cl*	431	O=O	494
C=N	613	H-Br	364	O=S	469
C≡N	890	H-I	299	P-P	197
C-O	335	H-N	389	S-S	268
C=O	707	H-O	463	F-F	150
C-F	484	H-S	338	*Cl*-*Cl*	242
C- *Cl*	326	H-Si	376	Br-Br	193
C-Br	276	H-H	436.4	I-I	151
C-I	238	N-N	159	N-F	275

Endo and Exo

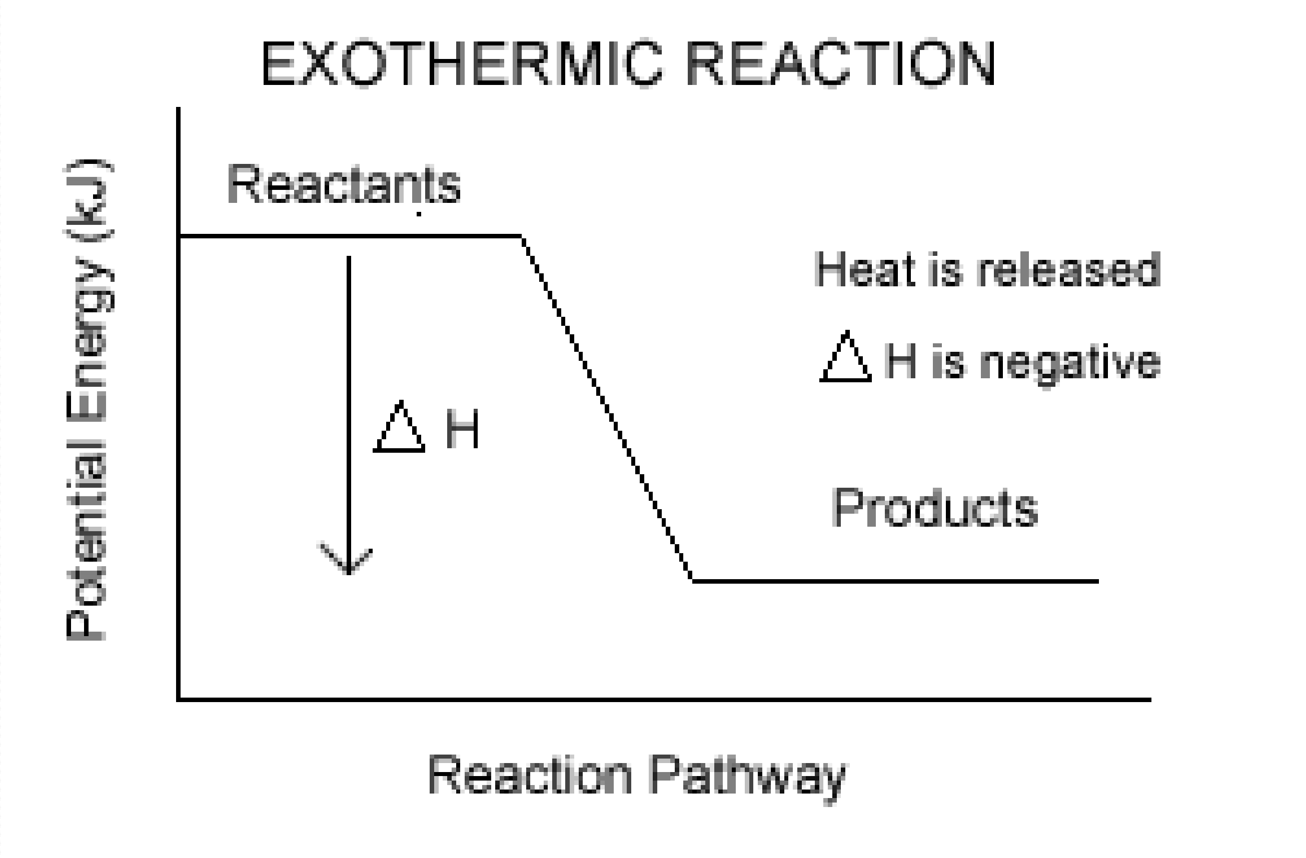


+ energy1
bond breaking
endothermic
molecule
separate atoms
bond making
exothermic
separate atoms
molecules
+ energy2

Combustion of Octane



Potential Energy Diagram



Heat of Combustion

- When energy is released during combustion we use the symbol $\Delta_c H°$
- When energy is released during combustion it is called exothermic (exit = exo, heat = thermic)
- Because energy is released (lost) we express it with a negative symbol

Heat vs. Temperature

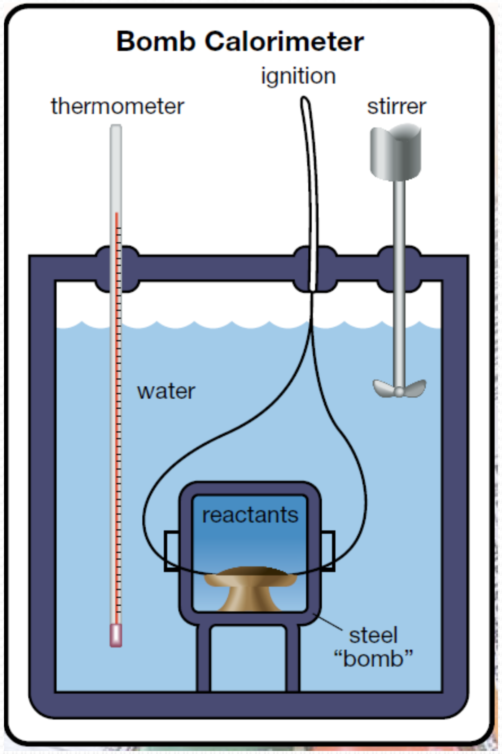
- You cannot directly measure thermal energy but you can measure temperature
- **Temperature** is a measure of average kinetic energy of the particles of a substance
- If temperature was a direct measurement of energy, all substances would change temperature at the same rate
- Since all substances do not change temperature at the same rate we must define something called **specific heat capacity**

Calories in Food

- A **calorie** is the amount of energy required to raise 1 g of water 1 degree Celsius
- 1 calorie = 4.19 J
- Calorie with a capital C, which you find of food labels means 1000 calories, or a kilocalorie
- We eat food to give us energy, so when we eat it is the same as burning a piece of wood
- Most of our body's energy comes from carbohydrates
- Before your body uses this energy it needs to convert it to glucose ($C_6H_{12}O_6$)

Calorimeter

- A calorimeter is a device used to measure energy changes



Standard Heats of Formation

- Another way of calculating energy released in a reaction is using the heats of formation
  - (energy it takes to form a compound) to estimate potential energy.
- Elements are used an arbitrary reference point and are given an energy of zero
- All standard heats of formation are given on page 5 of your data booklet

Standard Heats of Formation of Selected Compounds at 25°C

Compound	Formula	$\Delta_f H°$ (kJ/mol)
ammonia	$NH_3(g)$	−45.9
benzene	$C_6H_6(l)$	+49.1
butane	$C_4H_{10}(g)$	−125.7
calcium carbonate	$CaCO_3(s)$	−1 207.6
calcium hydroxide	$Ca(OH)_2(s)$	−985.2
carbon dioxide	$CO_2(g)$	−393.5

Hess's Law

- Hess's Law is a way of calculating the heat released in a combustion reaction, from the heats of formation
- Hess's Law Formula:

$$\Delta_r H = \sum n \Delta_f H^\circ \text{ products} - \sum n \Delta_f H^\circ \text{ reactants}$$

Steps

1. Divide into products and reactants.
2. Identify # moles for each
3. Assign values from page 5 table.
4. Total and subtract from each other.

-802.5 kJ

Example

- Calculate the heat released when methane combusts

$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$$

	Products		Reactants	
substance	CO_2	H_2O	CH_4	O_2
Coefficient	1	2	1	2
Standard Heat of formation	-393.5	-241.8	-74.6	0

Example

- Calculate the heat released when ethanol combusts

$$C_2H_5OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(g)$$

-1234.8 kj

Board Question

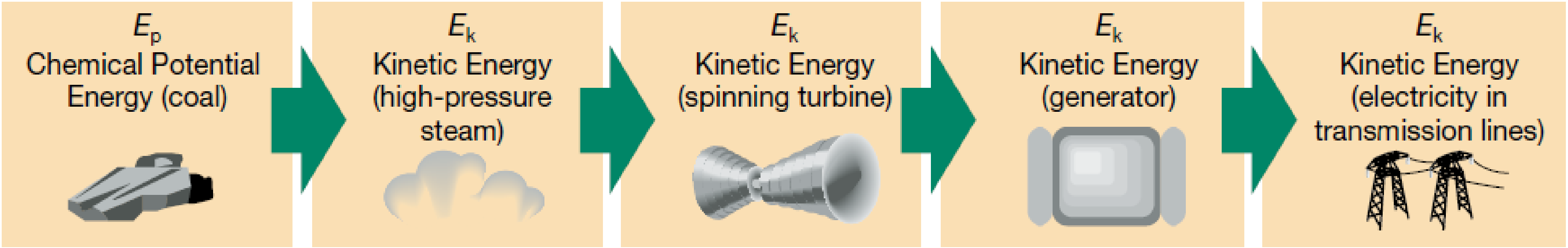
- Calculate the heat released when butane combusts

$$2\ C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8\ CO_2(g) + 10\ H_2O(g)$$

-5314.6 kj

Efficiency

- All of the energy calculated using Hess's Law does not always make it to you
- Lots of energy conversions have to happen before the energy can make it to the consumer in a usable form
- Here is an example using a coal power plant:



Sample Diploma Problem

9. The equation that can be used to determine the quantity of energy released during natural gas combustion is

A. $v = f\lambda$

B. $\Delta E = \Delta mc^2$

C. $C_iV_i = C_fV_f$

D. $\Delta_r H = \sum n\Delta_f H°$ products $- \sum n\Delta_f H°$ reactants

Sample Diploma Problem

Use the following information to answer questions 10 and 11.

Methane gas is collected from the decaying biological material in a sludge tank and is burned to produce heat and electricity for a waste-water treatment plant. The combustion of the collected methane gas is represented by the equation below.

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$$

11. The energy released from the combustion of one mole of methane gas is

A. 74.6 kJ

B. 560.7 kJ

C. 802.5 kJ

D. 951.7 kJ

{(-393.50) + (2*-241.8)] – [-74.6 + 0] = -802.5