Unit 3
Industrial Chemistry and Hess's law

Go to question

1 In the production of ammonia in the Haber Process, Which is a raw material used in this process?

2 A sulphuric acid plant needs to increase its production of acid over a period of just one month. Which line in the Table best describes the increase in costs?

3 An example of value adding would be …….

4 What is the relationship between a,b,c (Hess's Law)

5 Use the information above to calculate the ΔH_f for methane.

6 For this reaction to be economical certain conditions of pressure and temperature are used. Which of the conditions below are used?

1 Which of the following a raw material is used in the production of ammonia by the Haber Process ?

a. Iron used as a catalyst

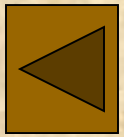
b. Hydrogen

c. Nitrogen

d. Recycled ammonia gas

a hint!!!!

A raw material is something obtained from nature which does not need processing.

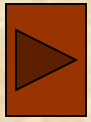


Which of the following a raw material is used in the production of ammonia by the Haber Process ?

Correct because……

Nitrogen

A raw material can either be non-living or living.
Raw materials are available, therefore, from our surroundings.
Nitrogen can be obtained from the fractional distillation of liquid air.

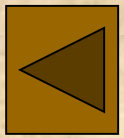


2 A sulphuric acid plant needs to increase its production of acid over a period of just one month. Which line in the table best describes the increase in costs?

	Capital Costs	Fixed Costs	Variable Costs
A	Increase	Increase	Increase
B	Stay the same	Stay the same	Stay the same
C	Stay the same	Increase	Stay the same
D	Stay the same	Stay the same	Increase

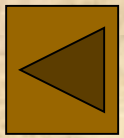
a hint!!!!

Capital costs would be such things as the cost of building the chemical plant.



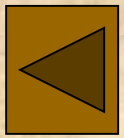
a hint!!!!

Fixed costs include the cost of the staff and local rates, which will not usually change over a short period.



a hint!!!!

Variable costs change throughout the year and change depending upon how much product is produced.



A sulphuric acid plant needs to increase its production of acid over a period of just one month. Which line in the Table best describes the increase in costs?

Correct because……

Capital costs: The cost of building the plant and the associated costs of all buildings, **would not increase**.

Fixed costs: The cost of the staff, local rates, advertising and utility bills **would not increase**.

Variable costs: The cost that changes throughout the year and is dependant of how much product is sold **would increase**.

Ans: **D**

3 An example of value adding to the product would be

a. Changing from a batch to a continuous process

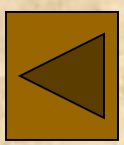
b. Changing naphtha in to polymers

c. Using a heat exchanger to recycle waste heat

d. Using a catalyst to increase yield.

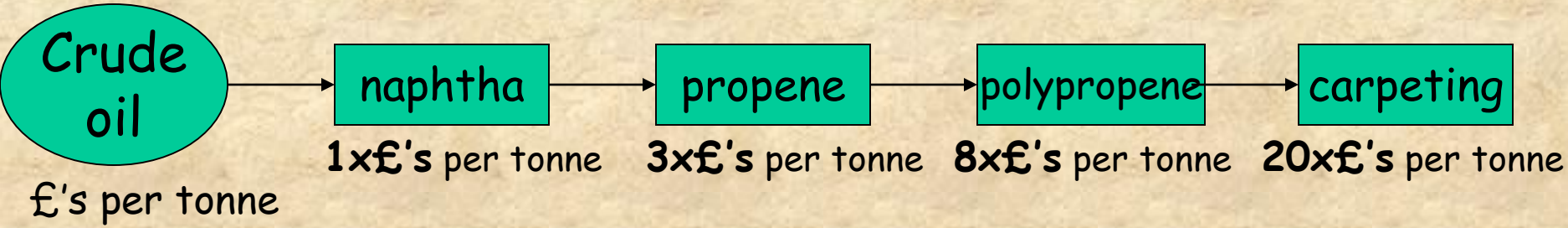
a hint!!!!

Adding value increases the selling price of your product.



An example of value adding to a product would be

b. Correct because…….



Changing naphtha into polymers adds value to the product to be sold.

4 What is the relationship between a,b,c

$C_6H_6(l) + 3H_2(g) \rightarrow C_6H_{12}(l)$ **ΔH a**

$C_6H_{12}(l) + 9\ O_2(g) \rightarrow 6H_2O(g) + 6CO_2(g)$ ΔH b

$C_6H_6(l) + 7\frac{1}{2}O_2(g) \rightarrow 3H_2O(g) + 6CO_2(g)$ ΔH c

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$ ΔH d

a. a = b +c + d

b. a = b + c + 3d

c. a = c + 3d - b

d. a = b - c + 3d

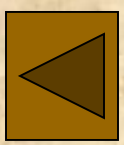
a hint!!!!

Consider the reverse of this reaction

$C_6H_{12}(l) + 9\ O_2\ (g) \rightarrow 6H_2O(g) + 6CO_2(g)$

a hint!!!!

Consider the number of moles of hydrogen needed.



What is the relationship between a,b,c

$C_6H_6(l) + 3H_2(g) \rightarrow C_6H_{12}(l)$ ΔH a

$C_6H_{12}(l) + 9\,O_2(g) \rightarrow 6H_2O(g) + 6CO_2(g)$ Sign change ΔH b

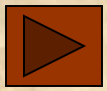
$C_6H_6(l) + 7\frac{1}{2}O_2(g) \rightarrow 3H_2O(g) + 6CO_2(g)$ ΔH c

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$ X 3 ΔH d

Correct because…….

In order to produce $C_6H_{12\,(l)}$ by an alternative route The combustion of each of the reactants needs to be considered as well as the reverse of the combustion of the product $C_6H_{12}(l)$.

Ans: c. a = c + 3d – b



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$C(s) + 2H_2(g) \longrightarrow CH_4(g)$ $\quad \Delta H_f = ?$

$C(s) + O_2(g) \longrightarrow CO_2(g)$ $\quad \Delta H_c =$ **-394 kJ mol $^{-1}$**

$H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(l)$ $\quad \Delta H_c =$ **-286 kJ mol $^{-1}$**

$CH_4(g) + 2 O_2(g) \longrightarrow CO_2(g) + 2 H_2O(l)$ $\quad \Delta H_c =$ **-891 kJ mol $^{-1}$**

Use the information above to calculate the ΔH_f for methane.

a. +211 kJ mol $^{-1}$

b. -75 kJ mol $^{-1}$

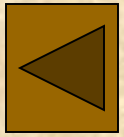
c. -1857 kJ mol $^{-1}$

d. -4171 kJ mol $^{-1}$

a hint!!!!

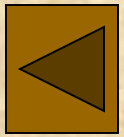
Consider the reverse of this reaction

$CH_4(g) + 2\ O_2\ (g) \longrightarrow CO_2(g) + 2\ H_2O\ (l)$



a hint!!!!

Consider the number of moles of hydrogen needed



a hint!!!!

Consider the number of moles of hydrogen needed

Consider the reverse of this reaction

$CH_4(g) + 1.5\ O_2\ (g) \longrightarrow CO_2(g) + H_2O\ (l)$

Use the information above to calculate the ΔH_f for methane.

$C(s) + 2H_2(g) \longrightarrow CH_4(g)$ $\quad \Delta H_f = ?$

$C(s) + O_2(g) \longrightarrow CO_2(g)$ $\quad \Delta H_c = \mathbf{-394\ kJ\ mol^{-1}}$

$H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(l)$ $\quad \Delta H_c = \mathbf{-286\ kJ\ mol^{-1}}$

$CH_4(g) + 2\,O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(l)$ $\quad \Delta H_c = \mathbf{-891\ kJ\ mol^{-1}}$

Correct because……..

The combustion of the reactants

1st $C(s) + O_2(g) \longrightarrow CO_2(g)$ **+** **x2** $H_2(g) + 0.5\,O_2(g) \longrightarrow H_2O(l)$

2nd and the reverse of the combustion of methane

$= -394 + (2x - 286) + (+ 891)$

$= \mathbf{-75\ kJ\ mol^{-1}}$

6

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) \qquad \Delta H = -92\ kJ$$

For this reaction to be economical, certain conditions of pressure and temperature are used. Which of the conditions below are used?

a. Low pressure and high temperature

b. High pressure and high temperature

c. Low pressure and low pressure

d. High pressure and low temperature

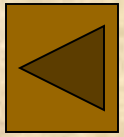
a hint!!!!

The equilibrium will shift in the direction that will reduce the change in pressure.
Pressure is linked to the number of molecules.

The equilibrium will shift in the direction that will reduce the change in temperature. $-\Delta H$ is exothermic

a hint!!!!

The equilibrium will shift in the direction that will reduce the change in temperature. $-\Delta H$ is exothermic
For economic reasons, the rate of the chemical reaction has also to be considered.



a hint!!!!

The equilibrium will shift in the direction that will reduce the change in pressure.
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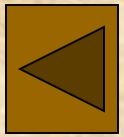
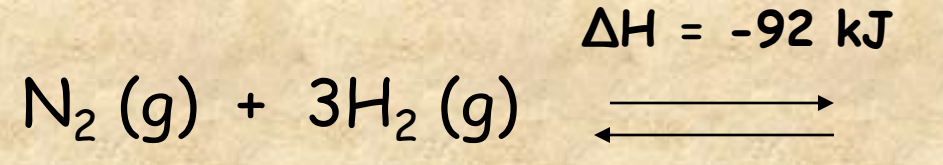


6. For this reaction to be economical certain conditions of pressure and temperature are used. Which of the conditions below are used?

Correct because…



High pressure will shift the equilibrium to the right. This results in less gas molecules but increases the amount of ammonia. A pressure of 150-300 atmospheres is used.
As the forward reaction on exothermic, the reverse reaction would be endothermic. So any addition of heat would mean that the equilibrium would shift to the left.
So a low temperature should be used.
However, this would mean the reaction would slow down, so in reality a compromise is reached and a temperature of between 400-500^{o} C is used, highish!!!