



AS Level Chemistry

CHEMICAL ENERGETICS

9701-MCQ

2026 EDITION

Q1 - Easy

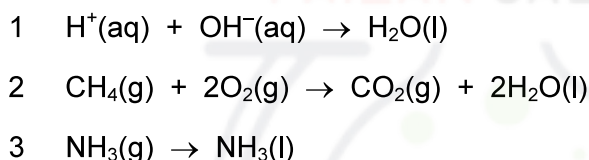
9701/11/O/N/23/Q9

- 9 Which statement about enthalpy changes is correct?
- A Enthalpy changes of reaction are always negative.
 - B Enthalpy changes of combustion are always positive.
 - C Enthalpy changes of formation are always positive.
 - D Enthalpy changes of neutralisation are always negative.

Q2 - Easy

9701/11/O/N/24/Q10

- 10 Three processes are described.



Which statement is correct?

- A None of the processes have a positive enthalpy change.
- B Only process 1 has a positive enthalpy change.
- C Only process 2 has a positive enthalpy change.
- D Only process 3 has a positive enthalpy change.

Q3 - Hard

9701/12/O/N/25/Q10

- 10 One commercially available 'heat pad' contains iron, activated carbon and water. The 'heat pad' is activated by air. This causes the pad to get hotter.

Which statement describes the chemical reaction occurring in the 'heat pad' when it is exposed to air?

- A The reaction is endothermic and iron gains electrons.
- B The reaction is endothermic and iron loses electrons.
- C The reaction is exothermic and iron gains electrons.
- D The reaction is exothermic and iron loses electrons.

Q4 - Easy

9701/11/M/J/21/Q11

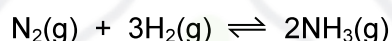
11 Which statement about catalysts is correct?

- A They change the reaction pathway by increasing the activation energy.
- B They increase the rate of reaction by lowering the enthalpy change of the reaction.
- C They increase the number of particles that have sufficient energy to react.
- D Heterogeneous catalysts are in the same state as the reactant.

Q5 - Easy

9701/12/O/N/22/Q11

11 The Haber process is carried out with a nitrogen partial pressure of 50 kPa, a hydrogen partial pressure of 150 kPa, a temperature of 400 °C and an iron catalyst.



If all other conditions are kept the same, which change will result in a raised activation energy?

- A Both the nitrogen and hydrogen partial pressures are changed to 100 kPa.
- B The iron is removed.
- C The nitrogen partial pressure is increased to 150 kPa.
- D The temperature is increased to 500 °C.

Q6 - Easy

9701/13/M/J/22/Q16

16 When the temperature of a particular reaction is increased by 10 °C (e.g. from 20 °C to 30 °C) the rate of the reaction approximately doubles.

What is the **most** significant reason for this increase?

- A a different mechanism for the reaction
- B an increased collision frequency of the reactant molecules
- C more collisions have energy greater than the activation energy
- D a reduced activation energy for the reaction

Q7 - Hard

9701/11/O/N/23/Q15

- 15 The forward reaction of a reversible reaction is exothermic and has an activation energy of $+30 \text{ kJ mol}^{-1}$.

The reverse reaction proceeds by a mechanism that is the exact reverse of the mechanism of the forward reaction.

Which statement about the activation energy of the reverse reaction is correct?

- A The activation energy for the reverse reaction is equal to -30 kJ mol^{-1} .
- B The activation energy for the reverse reaction is greater than 0 kJ mol^{-1} but less than $+30 \text{ kJ mol}^{-1}$.
- C The activation energy for the reverse reaction is equal to $+30 \text{ kJ mol}^{-1}$.
- D The activation energy for the reverse reaction is greater than $+30 \text{ kJ mol}^{-1}$.

Q8 - Hard

9701/12/M/J/23/Q15

- 15 The equations for two reactions are shown.



The two reactions have similar reaction mechanisms.

The initial rate of reaction X is greater than that of reaction Y when measured under identical conditions of temperature, pressure and reactant concentration.

Which statements explain this difference?

- 1 The activation energy for reaction X is less than that of reaction Y.
- 2 The Br-Br bond is weaker than the Cl-Cl bond.
- 3 A higher frequency of collisions between molecules of NOBr occur than between molecules of NOCl.

- A 1 and 2 B 2 and 3 C 1 only D 3 only

Q9 - Hard

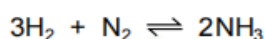
9701/13/M/J/20/Q34

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

34 The Haber process is used in industry to form ammonia from hydrogen and nitrogen.



Which statements about the activation energy for this process are correct?

1. The activation energy for the forward reaction is the same as the activation energy for the reverse reaction.
2. The activation energy for the reverse reaction is decreased by the addition of iron.
3. The activation energy is the minimum energy that colliding particles must possess in order to react.

Q10 - Hard

9701/12/M/J/20/Q32

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

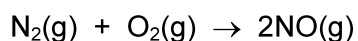
33 Which factors can lead to an increase in the rate of a reaction?

- 1** a lower activation energy
- 2** an increase in temperature
- 3** an increase in the concentration of a reactant

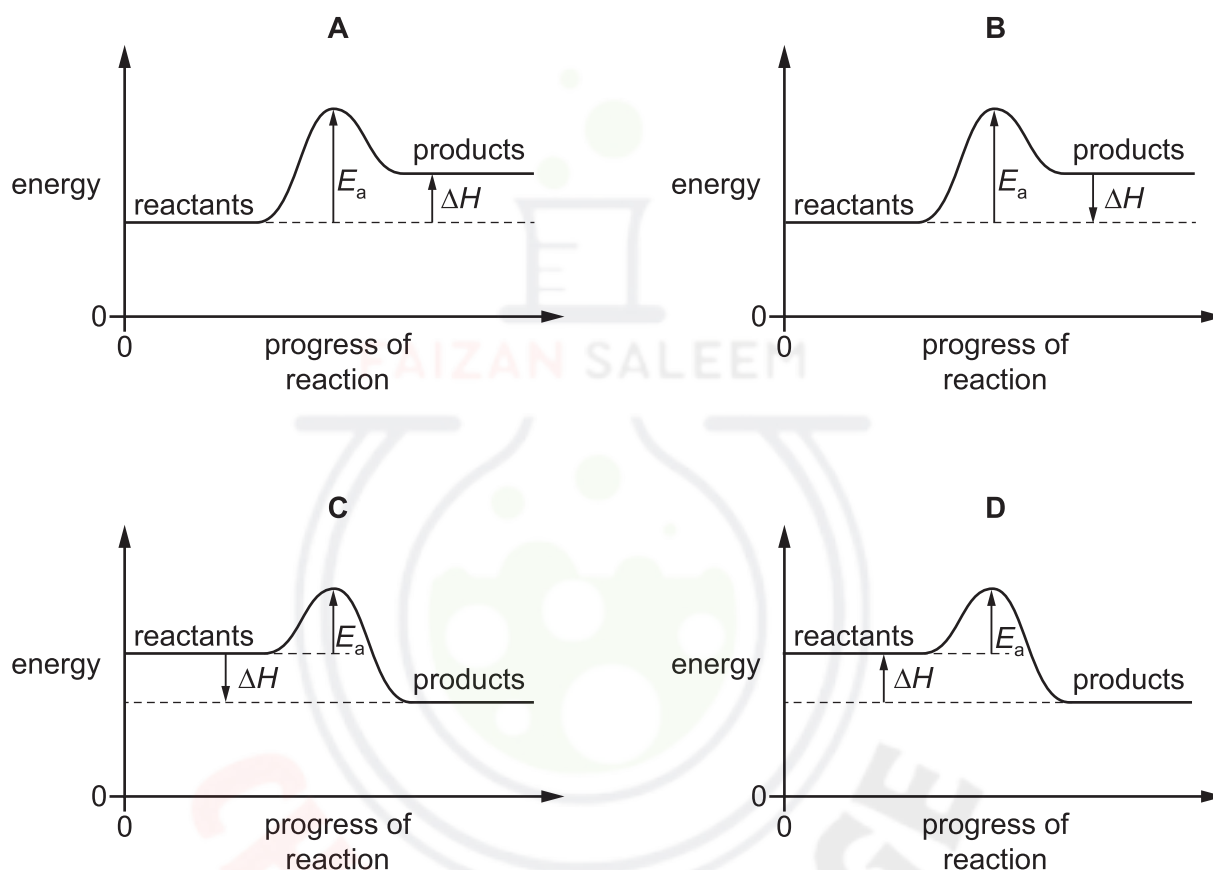
Q11 - Easy

9701/12/F/M/22/Q9

- 9 Nitrogen monoxide is an atmospheric pollutant that is formed inside car engines by an endothermic reaction between nitrogen and oxygen.



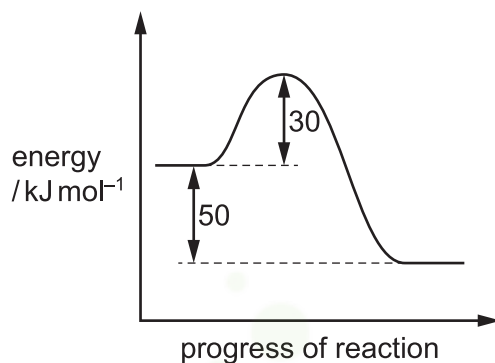
Which diagram correctly represents the energy profile for this reaction?



Q12 - Easy

9701/12/O/N/22/Q9

- 9 The reaction pathway for the forward reaction of a reversible reaction is shown.



Which statement is correct?

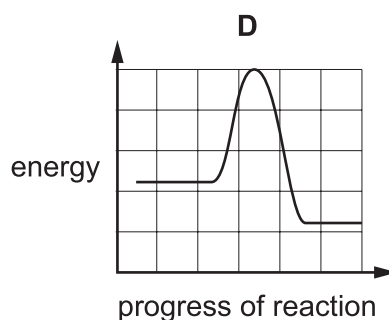
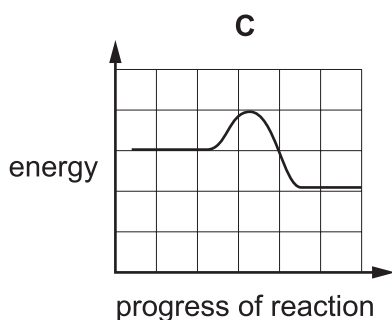
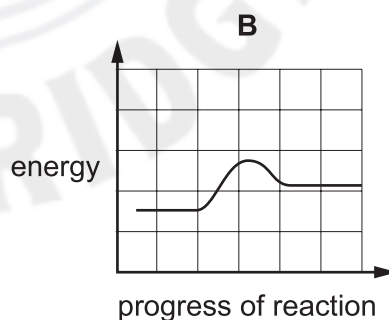
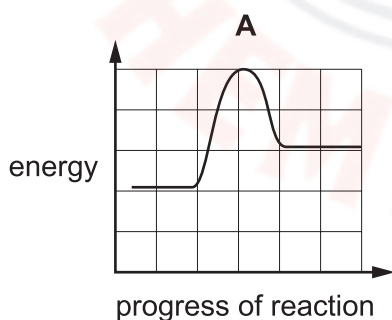
- A The activation energy of the reverse reaction is $+80 \text{ kJ mol}^{-1}$.
- B The enthalpy change for the forward reaction is $+30 \text{ kJ mol}^{-1}$.
- C The enthalpy change for the forward reaction is $+50 \text{ kJ mol}^{-1}$.
- D The enthalpy change for the reverse reaction is $+30 \text{ kJ mol}^{-1}$.

Q13 - Hard

9701/11/M/J/24/Q10

- 10 For a certain endothermic reaction, the activation energy is numerically equal to twice the enthalpy change of reaction.

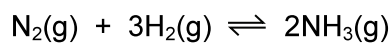
Which reaction pathway diagram is correct for this reaction?



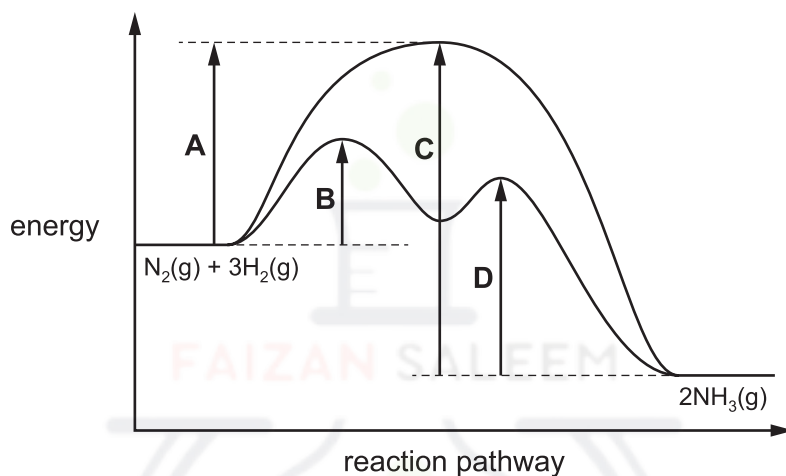
Q14 - Hard

9701/12/M/J/21/Q7

- 7 The reaction pathway diagram for the catalysed reaction and the uncatalysed reaction between N_2 and H_2 is shown.



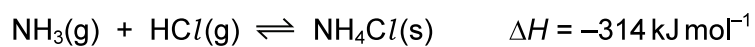
Which letter represents the activation energy for the first step in the decomposition of NH_3 in the presence of a catalyst?



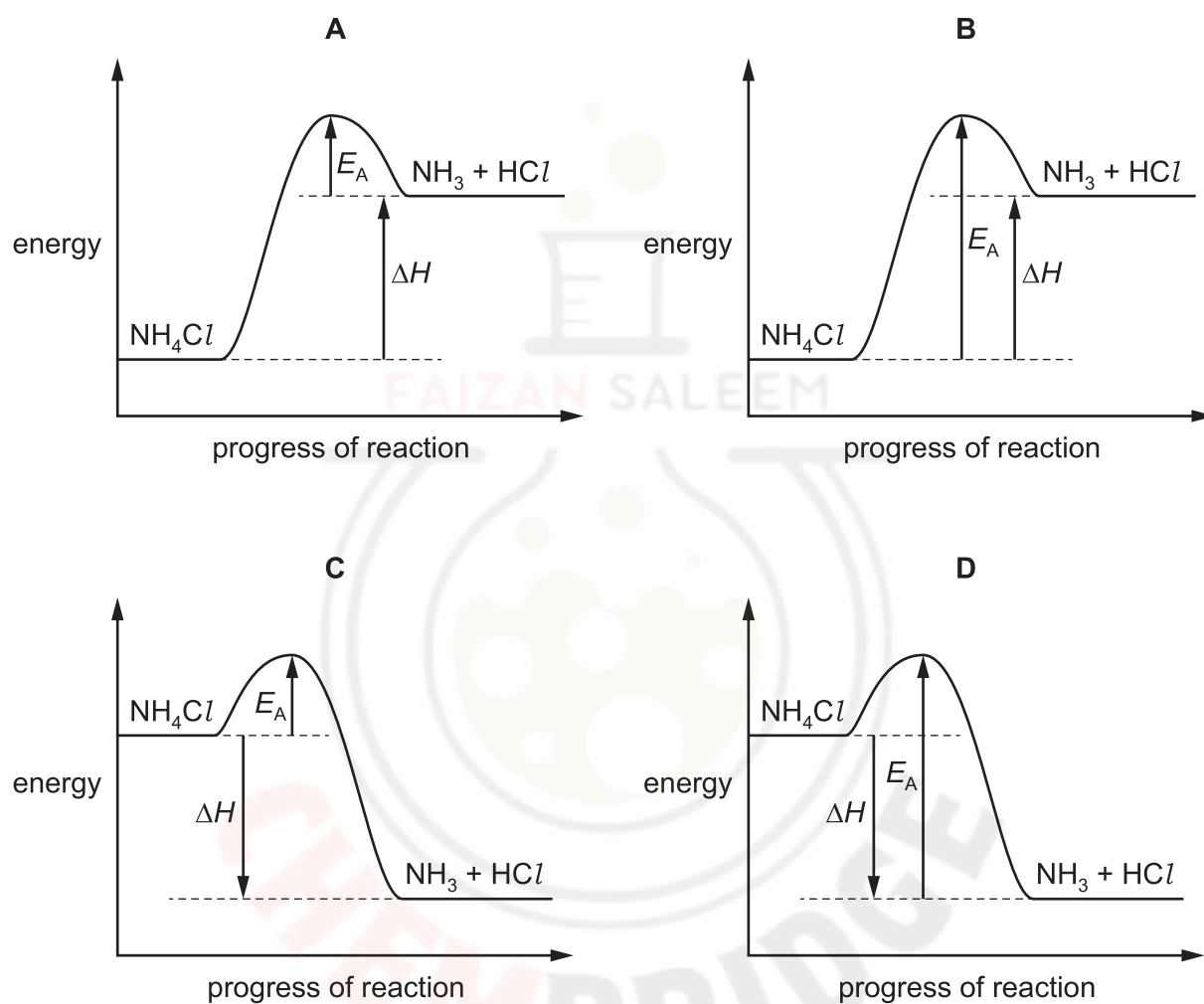
Q15 - Hard

9701/12/O/N/21/Q9

- 9 The equation for the formation of ammonium chloride is shown.



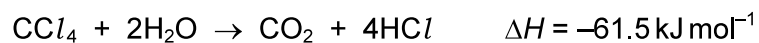
Which diagram shows the correctly labelled reaction pathway diagram for the decomposition of ammonium chloride?



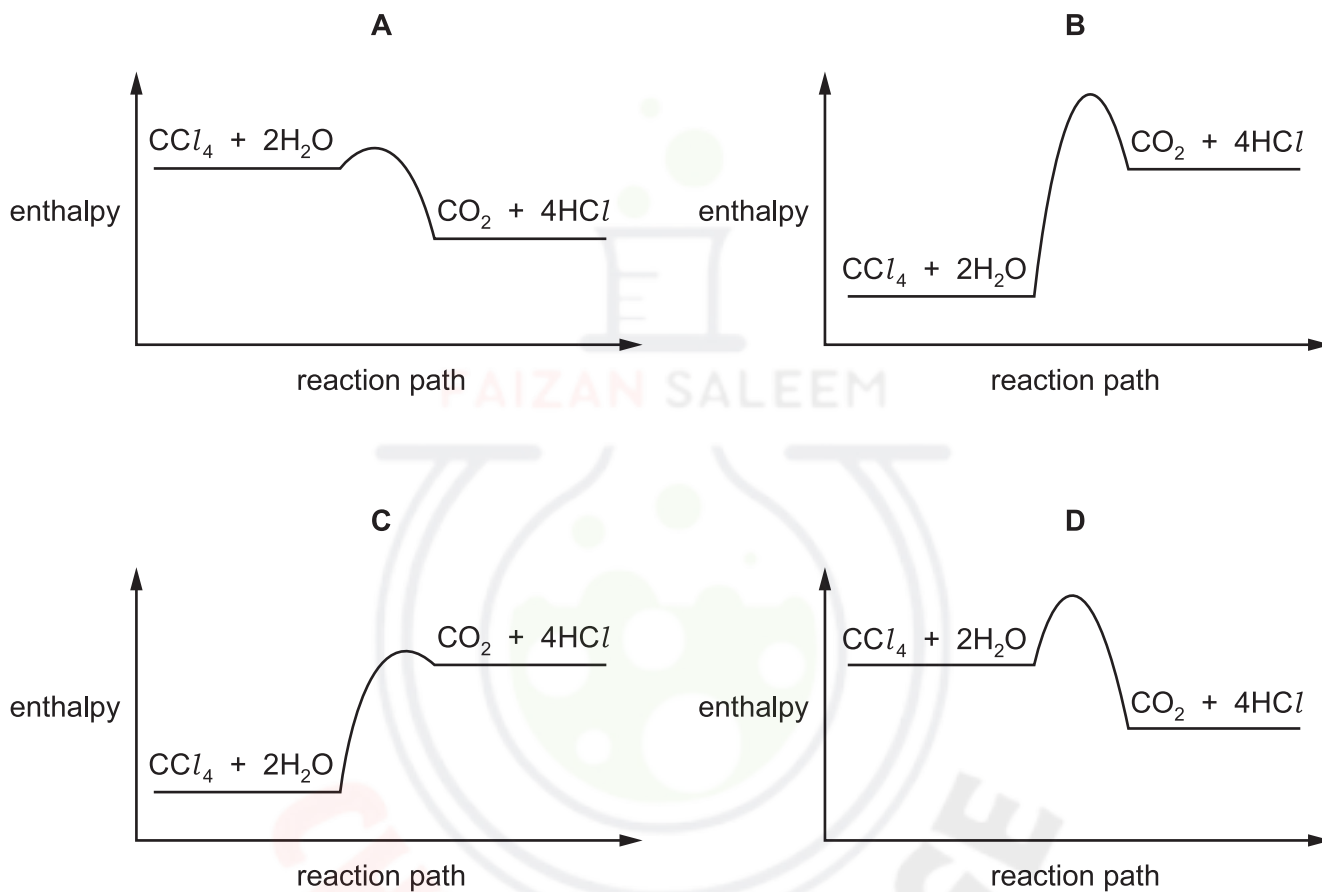
Q16 - Hard

9701/12/M/J/25/Q13

- 13 Under certain conditions, CCl_4 and H_2O react as shown. The activation energy for the reaction is $+62 \text{ kJ mol}^{-1}$.



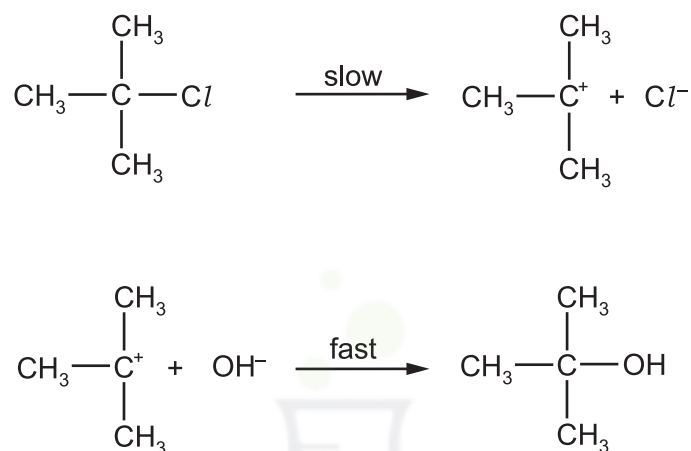
Which enthalpy profile diagram best fits this reaction?



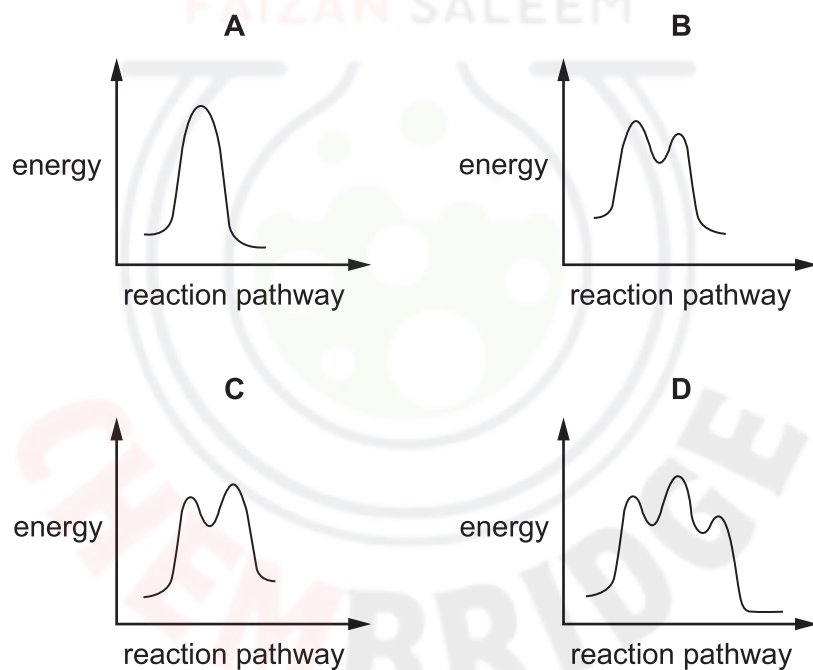
Q17 - Hard

9701/11/M/J/25/Q33

33 A possible mechanism for the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



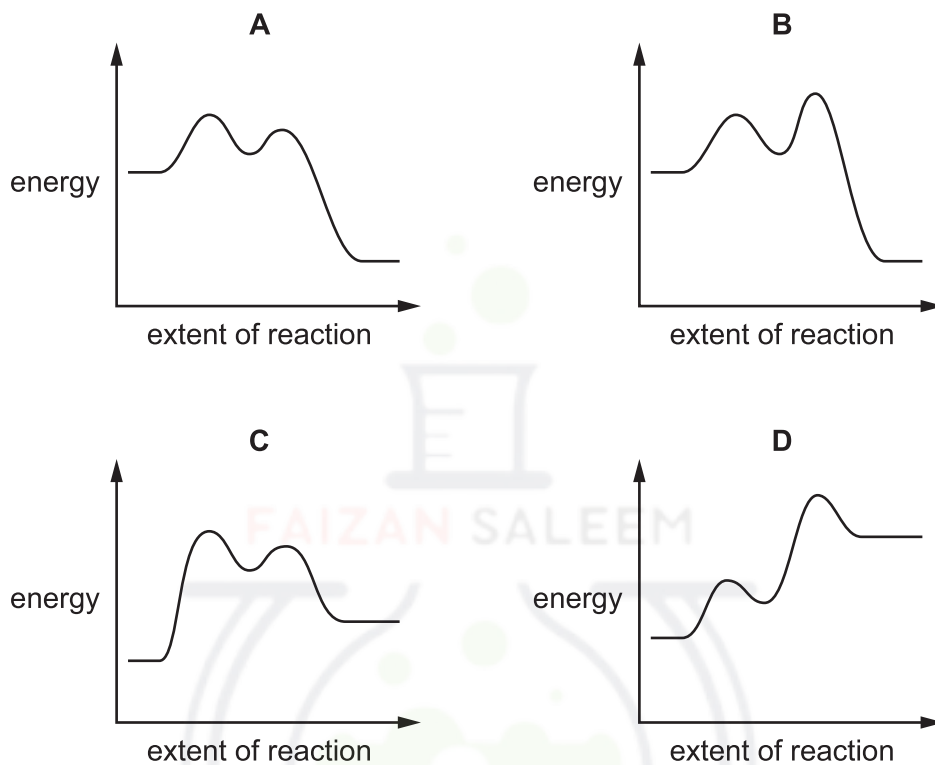
Which diagram represents the reaction pathway diagram for this mechanism?



Q18 - Hard

9701/12/O/N/25/Q15

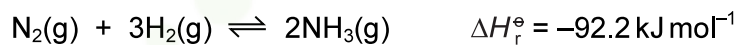
- 15 Which reaction pathway diagram shows an endothermic reaction that occurs in two steps and in which the second step of the reaction is likely to be faster than the first?



Q19 - Easy

9701/13/M/J/25/Q12

12 The equation for the reaction of nitrogen with hydrogen is shown.



Which statement is correct?

- A $\Delta H_r^\ominus$ is measured at 298 °C.
- B $\Delta H_r^\ominus$ is measured at 101 kPa.
- C $\Delta H_r^\ominus$ represents the standard enthalpy change for the formation of ammonia gas.
- D $\Delta H_r^\ominus$ represents the enthalpy change when 1.0 mol of $\text{N}_2(\text{g})$ reacts with 1.0 mol of $\text{H}_2(\text{g})$.

Q20 - Hard

9701/12/F/M/24/Q10

10 Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

- A $3\text{C}(\text{g}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$
- B $3\text{C}(\text{g}) + 8\text{H}(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$
- C $3\text{C}(\text{s}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$
- D $3\text{C}(\text{s}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{l})$

Q21 - Easy

9701/11/O/N/23/Q10

10 What is the definition of standard enthalpy change of neutralisation, $\Delta H_{\text{neut}}^{\ominus}$?

- A $\Delta H_{\text{r}}^{\ominus}$ when one mole of an aqueous acid is neutralised by an aqueous alkali
- B $\Delta H_{\text{r}}^{\ominus}$ when one mole of an aqueous alkali is neutralised by an aqueous acid
- C $\Delta H_{\text{r}}^{\ominus}$ when one mole of an aqueous acid is neutralised by one mole of an aqueous alkali
- D $\Delta H_{\text{r}}^{\ominus}$ when an aqueous acid and an aqueous alkali react together to produce one mole of water

Q22 - Easy

9701/12/O/N/24/Q9

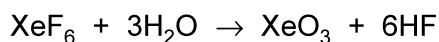
9 For which reaction is the enthalpy change an enthalpy change of formation?

- A $\text{C(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)}$
- B $\frac{1}{2}\text{N}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{NO(g)}$
- C $\text{Na}_2\text{O(s)} + \text{SO}_3\text{(g)} \rightarrow \text{Na}_2\text{SO}_4\text{(s)}$
- D $\text{PCl}_3\text{(g)} + \text{Cl}_2\text{(g)} \rightarrow \text{PCl}_5\text{(g)}$

Q23 - Hard

9701/12/F/M/23/Q10

10 The equation for a chemical reaction is shown. All substances are in their standard states.



Which statement describes the standard enthalpy change of reaction for this reaction?

- A the enthalpy change when a total of one mole of products is produced
- B the enthalpy change when a total of one mole of reactants is reacted
- C the enthalpy change when one mole of water reacts
- D the enthalpy change when six moles of hydrogen fluoride are produced

Q24 - Easy

9701/11/O/N/25/Q7

- 7 When 1.0 mol of ethanoic acid, CH_3COOH , in aqueous solution is neutralised by an excess of aqueous sodium hydroxide, 55 kJ mol^{-1} of energy is released.

Which statement about this reaction is correct?

- A The reaction is exothermic because only bond breaking takes place.
- B The reaction is exothermic because only bond forming takes place.
- C The reaction is exothermic because more energy is given out in breaking bonds than is taken in to form bonds.
- D The reaction is exothermic because more energy is given out in forming bonds than is taken in to break bonds.

Q25 - Hard

9701/12/F/M/25/Q15

- 15 All the reactants and products of an exothermic reaction are gaseous.

Which statement about this reaction is correct?

- A The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is negative.
- B The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is positive.
- C The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is negative.
- D The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is positive.

Q26 - Easy

9701/13/M/J/22/Q9

- 9 Which equation represents an enthalpy change that is the average bond energy of the C–H bond in methane?
- A $\frac{1}{4} \text{C(g)} + \text{H(g)} \rightarrow \frac{1}{4} \text{CH}_4\text{(g)}$
- B $\frac{1}{4} \text{CH}_4\text{(g)} \rightarrow \frac{1}{4} \text{C(g)} + \text{H(g)}$
- C $\text{CH}_4\text{(g)} \rightarrow \text{C(g)} + 4\text{H(g)}$
- D $\text{CH}_4\text{(g)} \rightarrow \text{CH}_3\text{(g)} + \text{H(g)}$

Q27 - Hard

9701/12/F/M/23/Q16

- 16 The table shows bond energies for some diatomic molecules. Deuterium, D, is an isotope of hydrogen.

bond	energy / kJ mol^{-1}
F–F	158
Cl–Cl	242
Br–Br	193
I–I	151
H–H	436
D–D	442

Which statements are correct?

- 1 Diatomic molecules have exact values for their bond energies, which are always positive.
 - 2 The trend in Group 7 bond energies can be explained by the variation in instantaneous dipole–induced dipole (id–id) forces.
 - 3 A value for the enthalpy change for the reaction between deuterium and chlorine can be calculated using these data alone.
- A 1 only B 1 and 2 only C 1 and 3 only D 2 and 3 only

Q28 - Easy

9701/13/M/J/23/Q13

13 Some bond energies are listed.

bond	bond energy / kJ mol^{-1}
H-H	436
O-H	463
O-O	146
O=O	496

One mole of hydrogen reacts with oxygen to give water vapour.

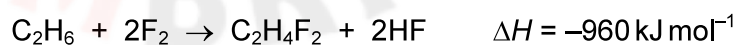
Using the bond energy data, what is the value for the enthalpy change of this reaction?

- A +221 kJ mol^{-1}
- B +6 kJ mol^{-1}
- C -242 kJ mol^{-1}
- D -417 kJ mol^{-1}

Q29 - Hard

9701/12/M/J/24/Q9

9 Ethane can react with fluorine to produce 1,2-difluoroethane, $\text{C}_2\text{H}_4\text{F}_2$.



bond	energy / kJ mol^{-1}
C-H	410
C-C	350
F-F	158
H-F	562

What is the bond energy of the C-F bond in 1,2-difluoroethane?

- A 407 kJ mol^{-1} B 474 kJ mol^{-1} C 486 kJ mol^{-1} D 972 kJ mol^{-1}

Q30 - Easy

9701/12/O/N/25/Q9

- 9 When 0.47 g of a hydrocarbon is completely burnt in air, the energy released heats 200 g of water from 23.7 °C to 41.0 °C.

What is the amount of energy absorbed, in Joules, by the water?

- A $0.47 \times 4.18 \times 17.3$
B $0.47 \times 4.18 \times (273 + 17.3)$
C $200 \times 4.18 \times 17.3$
D $200 \times 4.18 \times (273 + 17.3)$

Q31 - Easy

9701/11/O/N/21/Q7

- 7 In order to determine the enthalpy of neutralisation of a strong acid and a strong alkali, 25.0 cm³ of 2.00 mol dm⁻³ sodium hydroxide is added to 25.0 cm³ of 2.00 mol dm⁻³ hydrochloric acid. The increase in temperature is 12 °C.

In a second experiment, the same method is used, but 50.0 cm³ of 2.00 mol dm⁻³ sodium hydroxide is added to 50.0 cm³ of 2.00 mol dm⁻³ hydrochloric acid.

What is the increase in temperature in the second experiment?

- A 6 °C B 12 °C C 24 °C D 48 °C

Q32 - Easy

9701/11/O/N/22/Q10

- 10 A student mixes 25.0 cm³ of 0.350 mol dm⁻³ sodium hydroxide solution with 25.0 cm³ of 0.350 mol dm⁻³ hydrochloric acid. The temperature increases by 2.5 °C. No heat is lost to the surroundings.

The final mixture has a specific heat capacity of 4.2 J cm⁻³ K⁻¹.

What is the molar enthalpy change for the reaction?

- A -150 kJ mol⁻¹
B -60 kJ mol⁻¹
C -30 kJ mol⁻¹
D -0.15 kJ mol⁻¹

Q33 - Hard

9701/11/M/J/25/Q11

- 11 50 cm³ of 1.0 mol dm⁻³ H₂SO₄ is added to 100 cm³ of 1.0 mol dm⁻³ NaOH in an insulated vessel.

Both solutions are at a temperature of 20 °C before mixing. After mixing, the temperature rises and the highest temperature reached is 29 °C.

Assume that:

- all the energy released in the reaction goes into raising the temperature of the aqueous reaction mixture
- the specific heat capacity of the mixture is 4.2 J cm⁻³ K⁻¹.

What is the value of the enthalpy of neutralisation determined from this experiment?

- A -113.4 kJ mol⁻¹
B -56.7 kJ mol⁻¹
C -37.8 kJ mol⁻¹
D -18.9 kJ mol⁻¹

Q34 - Hard

9701/13/M/J/23/Q12

- 12 The enthalpy change for neutralisation of HNO₃(aq) with NaOH(aq) is -57.0 kJ mol⁻¹.

In an experiment, 20.0 cm³ of 4.00 mol dm⁻³ HNO₃ is mixed with 30.0 cm³ of 2.00 mol dm⁻³ NaOH in an insulated container. The initial temperature of both solutions is 25.0 °C.

It can be assumed that the heat capacity of the product mixture is 4.2 J cm⁻³ °C⁻¹ and that there are no heat losses.

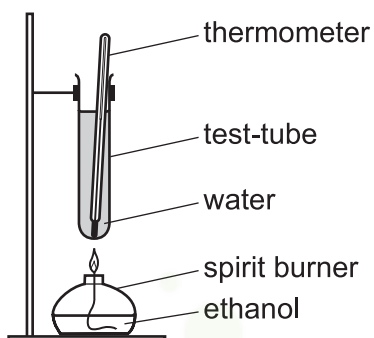
What is the maximum final temperature of the mixture?

- A 41.3 °C B 44.0 °C C 46.7 °C D 52.1 °C

Q35 - Hard

9701/12/F/M/21/Q7

- 7 An experiment was performed to determine the enthalpy of combustion of ethanol.



The data collected are shown.

mass of water = W g

mass of ethanol burned = X g

temperature rise = $Y^{\circ}\text{C}$

molar mass of ethanol = Z g mol $^{-1}$

specific heat capacity of water = 4.2 J K $^{-1}$ g $^{-1}$

Which expression can be used to calculate the enthalpy of combustion of ethanol in kJ mol $^{-1}$?

A $\frac{-4.2WYZ}{1000X}$

B $\frac{-4.2WYX}{1000Z}$

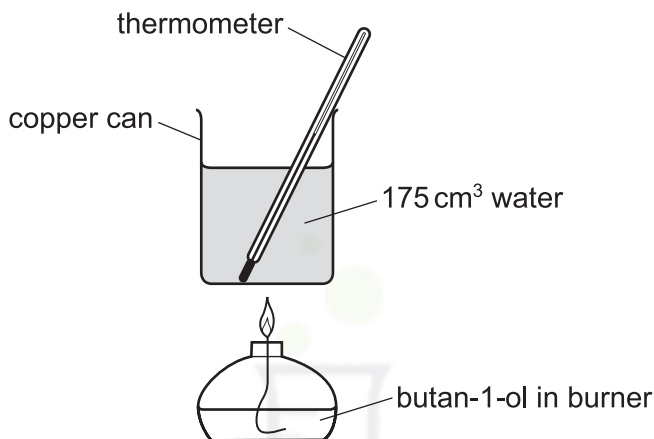
C $\frac{-4.2XYZ}{1000W}$

D $\frac{-4.2X(Y + 273)Z}{1000W}$

Q36 - Hard

9701/13/M/J/24/Q9

- 9 The apparatus used to determine a value for the enthalpy of combustion of butan-1-ol is shown. The mass of 1.00 cm^3 of water is 1.00 g .



initial mass of burner + butan-1-ol	58.34 g
initial temperature of water	17.6°C
final mass of burner + butan-1-ol	57.85 g
final temperature of water	41.1°C

butan-1-ol $M_r = 74$

Which value, to three significant figures, for the enthalpy of combustion of butan-1-ol can be calculated from these data?

- A -114 J mol^{-1}
B -17.2 kJ mol^{-1}
C -2600 kJ mol^{-1}
D -4540 kJ mol^{-1}

specific heat capacity of water	$c = 4.18\text{ kJ kg}^{-1}\text{ K}^{-1}$ ($4.18\text{ J g}^{-1}\text{ K}^{-1}$)
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Q37 - Hard

9701/11/O/N/25/Q8

- 8 In an experiment, 1.60 g of a fuel is burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0°C to 66.0°C .

What is the total energy released per gram of fuel burnt?

- A $25\,100\text{ J}$ B $55\,700\text{ J}$ C $89\,200\text{ J}$ D $143\,000\text{ J}$

Q38 - Hard

9701/12/M/J/22/Q10

- 10 Separate samples of 25.0 cm^3 of 0.1 mol dm^{-3} NaOH(aq) are added to each of three different acid solutions, as described. The temperature of each of the solutions was 298 K before mixing.

sample	acid	type of acid	concentration / mol dm^{-3}	volume / cm^3
1	H_2SO_4	strong	0.05	25.0
2	HCl	strong	0.05	25.0
3	$\text{CH}_3\text{CO}_2\text{H}$	weak	0.05	25.0

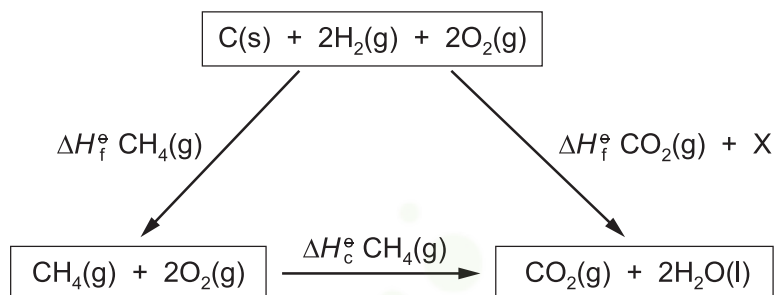
Which statement describes the temperature rises that occur on mixing each of these three acids separately with NaOH ?

- A The temperature rise in all three mixtures is the same.
- B The temperature rise using H_2SO_4 and HCl is the same.
- C The temperature rise using $\text{CH}_3\text{CO}_2\text{H}$ is greater than using HCl .
- D The greatest temperature rise occurs using H_2SO_4 .

Q39 - Easy

9701/13/M/J/21/Q8

8 Which enthalpy change is indicated by X in the enthalpy cycle shown?

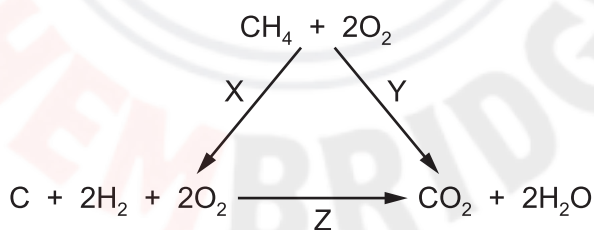


- A $-4 \times$ the enthalpy of combustion of hydrogen
- B $+4 \times$ the enthalpy of combustion of hydrogen
- C $-2 \times$ the enthalpy of formation of water
- D $+2 \times$ the enthalpy of formation of water

Q40 - Easy

9701/11/M/J/24/Q9

9 An energy cycle is shown.



The energy changes involved are X, Y and Z.

The numerical value of energy change Y is either -890 or $+890$.

The numerical value of energy change Z is either -964 or $+964$.

Which of the three values are negative?

- A X and Z
- B X only
- C Y and Z
- D Y only

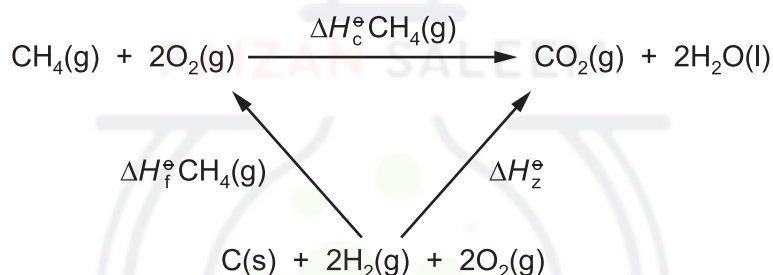
Q41 - Hard

9701/12/F/M/21/Q32

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 An energy cycle for the combustion of methane is shown.



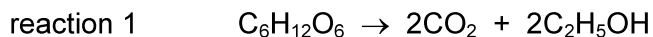
Which expressions can be used to calculate the energy change, ΔH_z° ?

- 1 $\Delta H_f^\circ \text{CH}_4(\text{g}) + \Delta H_c^\circ \text{CH}_4(\text{g})$
- 2 $\Delta H_c^\circ \text{C}(\text{s}) + 2\Delta H_c^\circ \text{H}_2(\text{g})$
- 3 $\Delta H_c^\circ \text{CO}(\text{g}) + 2\Delta H_c^\circ \text{H}_2(\text{g})$

Q42 - Hard

9701/12/F/M/22/Q8

8 The equation for reaction 1 is shown.



	$\Delta H_c^\circ / \text{kJ mol}^{-1}$
$\text{C}_6\text{H}_{12}\text{O}_6$	<i>a</i>
$\text{C}_2\text{H}_5\text{OH}$	<i>b</i>

What is the correct expression for the enthalpy change of reaction 1?

- A** $a + b$ **B** $a - b$ **C** $a + 2b$ **D** $a - 2b$

Q43 - Easy

9701/12/M/J/22/Q9

- 9 The standard enthalpy of formation of $\text{NO}_2(\text{g})$ is $+33.2 \text{ kJ mol}^{-1}$.

The standard enthalpy of formation of $\text{N}_2\text{O}_4(\text{g})$ is $+9.2 \text{ kJ mol}^{-1}$.

What is the standard enthalpy change for the reaction $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$?

- A $-57.2 \text{ kJ mol}^{-1}$
B $-24.0 \text{ kJ mol}^{-1}$
C $+42.4 \text{ kJ mol}^{-1}$
D $+75.6 \text{ kJ mol}^{-1}$

Q44 - Easy

9701/13/M/J/22/Q10

- 10 Magnesium carbonate decomposes when heated in a Bunsen burner flame.

Values for the standard enthalpies of formation, $\Delta H_f^\ominus$, of the species involved are shown.

$$\Delta H_f^\ominus \text{MgCO}_3 = -1095.8 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus \text{MgO} = -601.7 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus \text{CO}_2 = -393.5 \text{ kJ mol}^{-1}$$

What is the standard enthalpy change for the decomposition of magnesium carbonate?

- A $+100.6 \text{ kJ mol}^{-1}$
B $+887.6 \text{ kJ mol}^{-1}$
C $+1095.8 \text{ kJ mol}^{-1}$
D $+2091 \text{ kJ mol}^{-1}$

Q45 - Easy

9701/11/M/J/23/Q5

- 5 Calcium carbide, CaC_2 , reacts with water, as shown. The data below the equation show, in kJ mol^{-1} , the standard enthalpies of formation of the compounds involved.



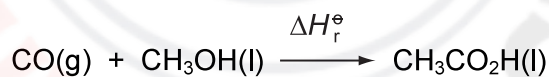
What is the standard enthalpy change of the reaction shown?

- A -753 kJ mol^{-1}
 B -61 kJ mol^{-1}
 C $+61 \text{ kJ mol}^{-1}$
 D $+753 \text{ kJ mol}^{-1}$

Q46 - Easy

9701/12/F/M/25/Q13

- 13 Carbon monoxide and methanol can react together to form ethanoic acid.



Standard enthalpy changes of combustion are given in the table.

compound	standard enthalpy change of combustion, $\Delta H_c^\ominus$
CO	$-283.0 \text{ kJ mol}^{-1}$
CH_3OH	$-726.0 \text{ kJ mol}^{-1}$
$\text{CH}_3\text{CO}_2\text{H}$	$-874.1 \text{ kJ mol}^{-1}$

What is the value for $\Delta H_r^\ominus$ for the reaction between carbon monoxide and methanol?

- A $-1883.1 \text{ kJ mol}^{-1}$
 B $-134.9 \text{ kJ mol}^{-1}$
 C $+134.9 \text{ kJ mol}^{-1}$
 D $+1883.1 \text{ kJ mol}^{-1}$

Q47 - Easy

9701/12/M/J/25/Q6

6 Some standard enthalpy of combustion data are given.

substance	standard enthalpy change of combustion / kJ mol^{-1}
C(s)	-394
H ₂ (g)	-286
CH ₃ OH(l)	-726

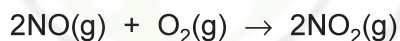
Using these data, what is the enthalpy change of formation of methanol?

- A -240 kJ mol^{-1} B -46 kJ mol^{-1} C 46 kJ mol^{-1} D 240 kJ mol^{-1}

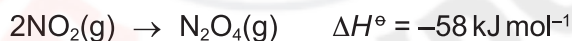
Q48 - Hard

9701/12/M/J/23/Q10

10 Nitrogen monoxide is rapidly oxidised to nitrogen dioxide.

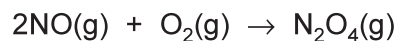


Nitrogen dioxide can then dimerise to form dinitrogen tetroxide.



$$\Delta H_f^\ominus \text{NO} = +91 \text{ kJ mol}^{-1} \text{ and } \Delta H_f^\ominus \text{NO}_2 = +34 \text{ kJ mol}^{-1}$$

What is the value of the standard enthalpy change for the reaction shown?



- A +56 kJ mol^{-1} B -1 kJ mol^{-1} C -115 kJ mol^{-1} D -172 kJ mol^{-1}

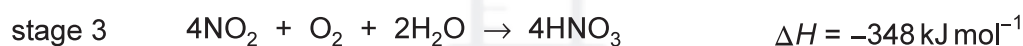
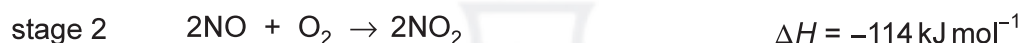
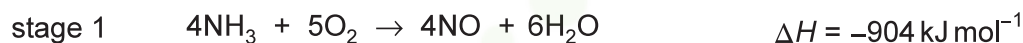
Q49 - Hard

9701/12/O/N/23/Q11

- 11 Nitric acid is made industrially by the oxidation of ammonia. The overall equation for the process is shown.



The process happens in three stages. The equations and enthalpy changes for these stages are given.



What is the enthalpy change of the process shown in equation 1?

- A $-1480 \text{ kJ mol}^{-1}$
- B -370 kJ mol^{-1}
- C $-341.5 \text{ kJ mol}^{-1}$
- D $+82 \text{ kJ mol}^{-1}$

Q50 - Hard

9701/11/O/N/24/Q9

- 9 The standard enthalpy change of combustion of carbon is -394 kJ mol^{-1} .

The standard enthalpy change of combustion of hydrogen is -286 kJ mol^{-1} .

The standard enthalpy change of formation of butane is -129 kJ mol^{-1} .

What is the standard enthalpy change of combustion of butane?

- A -551 kJ mol^{-1}
- B $-2877 \text{ kJ mol}^{-1}$
- C $-3135 \text{ kJ mol}^{-1}$
- D $-4307 \text{ kJ mol}^{-1}$

Q51 - Hard

9701/12/O/N/24/Q10

10 Two standard enthalpy change of formation values are given.

$$\Delta H_f^\ominus [\text{VCl}_2] = -452 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [\text{VCl}_3] = -573 \text{ kJ mol}^{-1}$$

What is the enthalpy change for the reaction $3\text{VCl}_2 \rightarrow 2\text{VCl}_3 + \text{V}$?

- A -210 kJ mol^{-1} B -121 kJ mol^{-1} C $+121 \text{ kJ mol}^{-1}$ D $+210 \text{ kJ mol}^{-1}$

Q52 - Hard

9701/12/F/M/24/Q9

9 The enthalpy change for a reaction can be calculated from values of:

- enthalpies of formation, $\Delta H_f^\ominus$
- enthalpies of combustion, $\Delta H_c^\ominus$
- bond energies, E .

The enthalpy change of the reaction given = $\Delta H_r^\ominus$.



Which expression could be used to calculate $\Delta H_r^\ominus$?

- A $\Delta H_c^\ominus(\text{C}_2\text{H}_6(\text{g}))$
 B $2\Delta H_c^\ominus(\text{C}_2\text{H}_6(\text{g})) - 2\Delta H_c^\ominus(\text{CH}_4(\text{g}))$
 C $E(\text{C}-\text{C}) + 2E(\text{C}-\text{H}) - 4E(\text{C}=\text{O}) - 4E(\text{H}-\text{O})$
 D $\Delta H_f^\ominus(\text{CH}_4(\text{g})) + \Delta H_f^\ominus(\text{CO}_2(\text{g})) + \Delta H_f^\ominus(\text{H}_2\text{O}(\text{l})) - \Delta H_f^\ominus(\text{C}_2\text{H}_6(\text{g}))$

Q53 - Hard

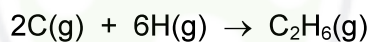
9701/12/O/N/22/Q16

16 Use relevant enthalpy changes from the tables to answer this question.

reaction	$\Delta H/\text{kJ mol}^{-1}$
$\text{C(s)} + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$	-76
$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$	-890
$\text{CH}_4(\text{g}) \rightarrow \text{C(g)} + 4\text{H(g)}$	1648
$3\text{C(s)} + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$	-105

bond	bond enthalpy / kJ mol^{-1}
H-H	436
C-C	350
C=C	610
C=O	805

Which value can be calculated for the enthalpy change for the following reaction?

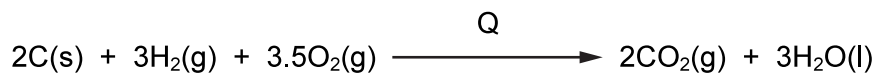


- A -2822 kJ mol^{-1}
- B -2122 kJ mol^{-1}
- C -1998 kJ mol^{-1}
- D -1772 kJ mol^{-1}

Q54 - Hard

9701/11/M/J/22/Q9

9 The equation for an enthalpy change is shown. The enthalpy change is Q.



What is the correct expression to calculate Q?

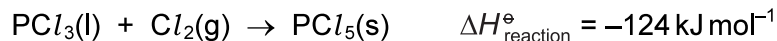
- A $2 \times \Delta H_{\text{c}}^{\ominus}[\text{CO}_2(\text{g})] - 3 \times \Delta H_{\text{f}}^{\ominus}[\text{H}_2(\text{g})]$
- B $3 \times \Delta H_{\text{f}}^{\ominus}[\text{H}_2\text{O}(\text{g})] + 2 \times \Delta H_{\text{c}}^{\ominus}[\text{CO}_2(\text{g})]$
- C $2 \times \Delta H_{\text{f}}^{\ominus}[\text{CO}_2(\text{g})] - 3 \times \Delta H_{\text{f}}^{\ominus}[\text{H}_2(\text{g})]$
- D $3 \times \Delta H_{\text{f}}^{\ominus}[\text{H}_2\text{O(l)}] + 2 \times \Delta H_{\text{f}}^{\ominus}[\text{CO}_2(\text{g})]$

Q55 - Hard

9701/11/O/N/22/Q9

- 9 The enthalpy changes of formation, $\Delta H_f^\ominus$, of both PCl_3 and PCl_5 are exothermic.

PCl_3 reacts with chlorine.



Which pair of statements is correct?

	statement 1	statement 2
A	$\Delta H_{\text{reaction}}^\ominus$ is less negative than $\Delta H_f^\ominus (\text{PCl}_5)$.	The Cl_2 bond energy is needed in calculating $\Delta H_{\text{reaction}}^\ominus$ from enthalpies of formation.
B	$\Delta H_{\text{reaction}}^\ominus$ is more negative than $\Delta H_f^\ominus (\text{PCl}_5)$.	The Cl_2 bond energy is needed in calculating $\Delta H_{\text{reaction}}^\ominus$ from enthalpies of formation.
C	$\Delta H_{\text{reaction}}^\ominus$ is less negative than $\Delta H_f^\ominus (\text{PCl}_5)$.	The Cl_2 bond energy is not needed in calculating $\Delta H_{\text{reaction}}^\ominus$ from enthalpies of formation.
D	$\Delta H_{\text{reaction}}^\ominus$ is more negative than $\Delta H_f^\ominus (\text{PCl}_5)$.	The Cl_2 bond energy is not needed in calculating $\Delta H_{\text{reaction}}^\ominus$ from enthalpies of formation.

Question	Answer	Original paper reference
1	D	9701/11/O/N/23/Q9
2	A	9701/11/O/N/24/Q10
3	D	9701/12/O/N/25/Q10
4	C	9701/11/M/J/21/Q11
5	B	9701/12/O/N/22/Q11
6	C	9701/13/M/J/22/Q16
7	D	9701/11/O/N/23/Q15
8	C	9701/12/M/J/23/Q15
9	C	9701/13/M/J/20/Q34
10	A	9701/12/M/J/20/Q33
11	A	9701/12/F/M/22/Q9
12	A	9701/12/O/N/22/Q9
13	B	9701/11/M/J/24/Q10
14	D	9701/12/M/J/21/Q7
15	B	9701/12/O/N/21/Q9
16	D	9701/12/M/J/25/Q13
17	B	9701/11/M/J/25/Q33
18	C	9701/12/O/N/25/Q15
19	B	9701/13/M/J/25/Q12
20	C	9701/12/F/M/24/Q10
21	D	9701/11/O/N/23/Q10
22	B	9701/12/O/N/24/Q9
23	D	9701/12/F/M/23/Q10
24	D	9701/11/O/N/25/Q7
25	C	9701/12/F/M/25/Q15
26	B	9701/13/M/J/22/Q9
27	A	9701/12/F/M/23/Q16
28	C	9701/13/M/J/23/Q13

Question	Answer	Original paper reference
29	C	9701/12/M/J/24/Q9
30	C	9701/12/O/N/25/Q9
31	B	9701/11/O/N/21/Q7
32	B	9701/11/O/N/22/Q10
33	B	9701/11/M/J/25/Q11
34	A	9701/13/M/J/23/Q12
35	A	9701/12/F/M/21/Q7
36	C	9701/13/M/J/24/Q9
37	B	9701/11/O/N/25/Q8
38	D	9701/12/M/J/22/Q10
39	D	9701/13/M/J/21/Q8
40	C	9701/11/M/J/24/Q9
41	B	9701/12/F/M/21/Q32
42	D	9701/12/F/M/22/Q8
43	A	9701/12/M/J/22/Q9
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50	B	9701/11/O/N/24/Q9
51	D	9701/12/O/N/24/Q10
52	B	9701/12/F/M/24/Q9
53	A	9701/12/O/N/22/Q16
54	D	9701/11/M/J/22/Q9
55	C	9701/11/O/N/22/Q9