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CHEMISTRY MULTIPLE CHOICE QUESTIONS

E. Chemical Energetics

2002 -2014

1.

Which statement about the standard enthalpy change of formation of carbon dioxide is correct?

A It is equal to the standard enthalpy change of combustion of carbon.

B It is equal to twice the bond energy of the C=O bond.

C It is the energy released when one mole of carbon dioxide is formed from carbon at the temperature of combustion of the carbon.

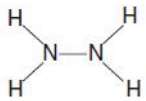
D It is the same for carbon dioxide produced from graphite and from diamond.

[2002 M/J (8)]

2.

Use of the Data Booklet is relevant to this question.

Hydrazine was used as a fuel for the Messerschmidt 163 rocket fighter in World War II and for the American Gemini and Apollo spacecraft. It has the following formula.



What is the enthalpy change of atomisation of 1 mol of gaseous hydrazine?

A 550 kJ

B 1720 kJ

C 1970 kJ

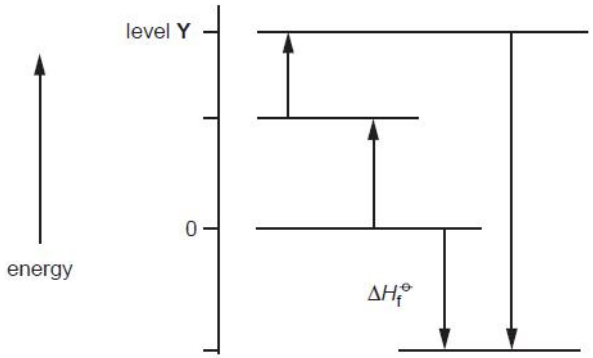
D 2554 kJ

[2002 M/J (9)]

3.

The following energy cycle represents the enthalpy changes in the formation of carbon dioxide from its constituent elements in their standard states.

What substances are present at level **Y** in this diagram?



A C(g) + 2O(g)

B C(g) + O_2(g)

C C(s) + O_2(g)

D CO_2(g)

[2002 O/N (9)]

4.

At 600 °C oxides of nitrogen react with unburnt hydrocarbons in a catalytic converter in a car exhaust. The equation using methane as representative of a hydrocarbon molecule would be as follows.

$$4NO + CH_4 \rightarrow 2N_2 + CO_2 + 2H_2O$$

Which statement is likely to be true about the energy change of this reaction?

A It is endothermic as heat energy is converted into chemical energy.

B It is exothermic as a high temperature is required.

C It is exothermic as the triple bond N $\rightleftharpoons$ O is broken.

D It is exothermic as the products have large negative enthalpy changes of formation.

[2002 O/N (10)]

5.

Gaseous phosphorus pentachloride can be decomposed into gaseous phosphorus trichloride and chlorine by heating. The table below gives the bond energies.

bond	bond energy / kJ mol^{-1}
P-C*l* (in both chlorides)	330
C*l*-C*l*	240

What is the enthalpy change in the decomposition of PCl_5 to PCl_3 and Cl_2?

A –120 kJ mol^{-1} **B** –90 kJ mol^{-1} **C** +90 kJ mol^{-1} **D** +120 kJ mol^{-1}

[2003 M/J (7)]

6.

The 'flash' produced by nineteenth century photographers to take indoor photographs was obtained from the following reaction.

$$3Mg + KClO_3 \longrightarrow 3MgO + KCl$$

The standard enthalpy changes of formation are given below.

	$\Delta H_f^\ominus$ / kJ mol^{-1}
MgO	–602
KC*l*	–437
$KClO_3$	–391

What is the standard enthalpy change of the 'flash' reaction?

A –3(–602) + (–437) – (–391)

B (–602) + (–437) – (–391)

C 3(–602) + (–437) – (–391)

D (–602) + 3(–437) – 3(–391)

[2003 O/N (11)]

Why does the exothermic reaction

$$C(diamond) \longrightarrow C(graphite) \qquad \Delta H = -3\ kJ\ mol^{-1}$$

not occur spontaneously?

A A tetrahedral configuration is always more stable than a planar one.

B Diamond has only strong covalent bonds whereas graphite has both covalent bonds and van der Waals' forces.

C The change from diamond to graphite has a high activation energy.

D The density of graphite is less than that of diamond.

[2003 O/N (12)]

8.

The standard enthalpy changes of formation of iron(II) oxide, FeO(s), and aluminium oxide, $Al_2O_3(s)$, are –266 kJ mol^{-1} and –1676 kJ mol^{-1} respectively.

What is the enthalpy change under standard conditions for the following reaction?

$$3FeO(s) + 2Al(s) \rightarrow 3Fe(s) + Al_2O_3(s)$$

A +878 kJ **B** –878 kJ **C** –1942 kJ **D** –2474 kJ

[2004 M/J (8)]

9.

The conversion of graphite has only a small positive value of ΔH.

$$C\ (graphite) \rightarrow C\ (diamond) \qquad \Delta H = +2.1\ kJ\ mol^{-1}$$

However, the production of synthetic diamonds using this reaction is very difficult.

Which statements help to explain this?

1 The activation energy of the reaction is large.

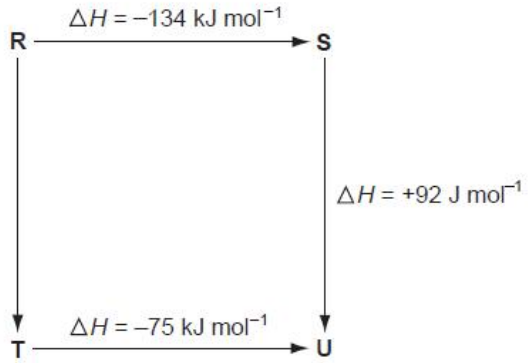
2 An equilibrium exists between diamond and graphite.

3 Only exothermic reactions can be made to occur readily.

[2004 M/J (32)]

10.

The diagram illustrates the energy changes of a set of reactions.



Which of the following statements are correct?

1 The enthalpy change for the transformation **U** ⟶ **R** is +42 kJ mol^{-1}.

2 The enthalpy change for the transformation **T** ⟶ **S** is endothermic.

3 The enthalpy change for the transformation **R** ⟶ **T** is –33 kJ mol^{-1}.

[2004 O/N (31)]

11.

Iodine trichloride, ICl_3, is made by reacting iodine with chlorine.

$$I_2(s) + Cl_2(g) \rightarrow 2ICl(s) \;;\; \Delta H^{\ominus} = +14\,kJ\,mol^{-1}$$

$$ICl(s) + Cl_2(g) \rightarrow ICl_3(s) \;;\; \Delta H^{\ominus} = -88\,kJ\,mol^{-1}$$

By using the data above, what is the enthalpy change of the formation for solid iodine trichloride?

A –60 kJ mol^{-1}

B –74 kJ mol^{-1}

C –81 kJ mol^{-1}

D –162 kJ mol^{-1}

[2005 M/J (7)]

12.

Which of the enthalpy changes of the following reactions can **only** be obtained by application of Hess' Law?

1 The hydration of anhydrous copper sulphate to form crystals of $CuSO_4.5H_2O$.

2 The formation of methane from its elements.

3 The combustion of glucose, $C_6H_{12}O_6$.

[2005 M/J (33)]

13.

Given $S(s) + O_2(g) \rightarrow SO_2(g)$, $\Delta H_f^{\ominus} = -297\,kJ\,mol^{-1}$

and $S(s) + 1\frac{1}{2}O_2(g) \rightarrow SO_3(g)$ $\Delta H_f^{\ominus} = -395\,kJ\,mol^{-1}$

what is the enthalpy change of reaction, $\Delta H^{\ominus}$, of $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$?

A –196 kJ mol^{-1} **B** –98 kJ mol^{-1} **C** +98 kJ mol^{-1} **D** +196 kJ mol^{-1}

[2005 O/N (6)]

14.

The table shows the enthalpy change of neutralisation per mole of water formed, ΔH, for various acids and bases.

acid	base	ΔH / kJ mol^{-1}
hydrochloric acid	sodium hydroxide	–57.0
P	sodium hydroxide	–54.0
hydrochloric acid	**Q**	–52.0
nitric acid	**R**	–57.0

What are **P**, **Q** and **R**?

	P	Q	R
A	ethanoic acid	ammonia	potassium hydroxide
B	ethanoic acid	sodium hydroxide	ammonia
C	sulphuric acid	ammonia	potassium hydroxide
D	sulphuric acid	sodium hydroxide	ammonia

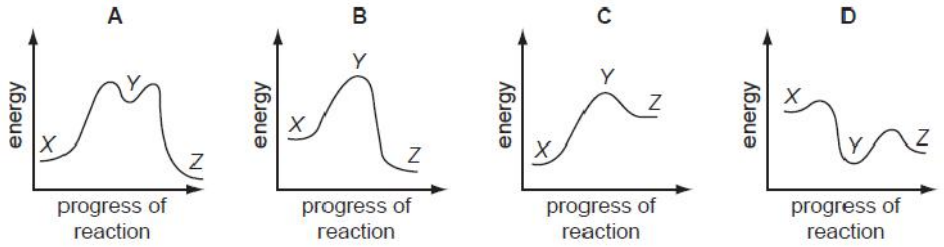
[2005 O/N (7)]

15.

In the conversion of compound *X* into compound *Z*, it was found that the reaction proceeded by way of compound *Y*, which could be isolated. The following steps were involved.

$X \rightarrow Y$; ΔH, positive
$Y \rightarrow Z$; ΔH, negative

Which reaction profile fits these data?



[2006 M/J (8)]

16.

Sodium ions can be formed from sodium atoms.

$$Na(s) \rightarrow Na^+(g)$$

Which quantities are required to calculate the enthalpy change of formation of gaseous sodium ions?

1 enthalpy change of atomisation of sodium

2 first ionisation energy of sodium

3 enthalpy change of formation of sodium

[2006 M/J (32)]

17.

For which equation is the enthalpy change correctly described as an enthalpy change of formation?

A $2NO(g) \rightarrow N_2(g) + O_2(g)$

B $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

C $H_2O(l) + NaCl(s) \rightarrow NaCl(aq)$

D $K(s) + Mn(s) + 2O_2(g) \rightarrow KMnO_4(s)$

[2006 O/N (8)]

18.

Given $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ $\Delta H^\ominus = -283\ kJ\ mol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H^\ominus = -286\ kJ\ mol^{-1}$

$H_2O(g) \rightarrow H_2O(l)$ $\Delta H^\ominus = -44\ kJ\ mol^{-1}$

what is the change in enthalpy, $\Delta H^\ominus$, for the following reaction?

$$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$$

A $-525\ kJ\ mol^{-1}$ **B** $-41\ kJ\ mol^{-1}$ **C** $+41\ kJ\ mol^{-1}$ **D** $+525\ kJ\ mol^{-1}$

[2006 O/N (9)]

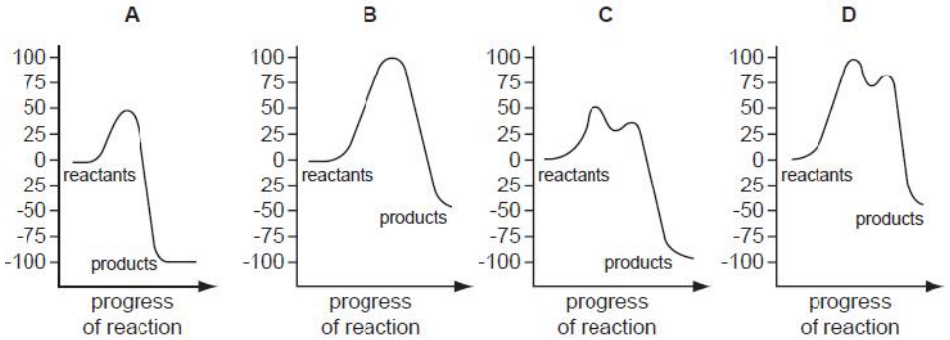
19.

An exothermic chemical reaction proceeds by two stages.

reactants —stage 1→ intermediate —stage 2→ products

The activation energy of stage 1 is $50\ kJ\ mol^{-1}$. The overall enthalpy change of reaction is $-100\ kJ\ mol^{-1}$.

Which diagram represents the reaction pathway for this reaction?



[2007 M/J (7)]

20.

Skiers trapped by snowstorms use heat packs to keep warm. The heat may be generated by the reaction below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \quad ; \quad \Delta H^{\ominus} = -1648\,kJ$$

What is the standard enthalpy change of formation of iron(III) oxide?

A $0\,kJ\,mol^{-1}$

B $-824\,kJ\,mol^{-1}$

C $-1648\,kJ\,mol^{-1}$

D $-3296\,kJ\,mol^{-1}$

[2007 M/J (8)]

21.

Slaked lime, $Ca(OH)_2$, may be made from limestone, $CaCO_3$.

On heating in a lime kiln at 1000 °C, limestone decomposes as follows.

reaction 1 $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Water is then reacted with calcium oxide, CaO, as follows.

reaction 2 $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

What are the enthalpy changes of these reactions?

	reaction 1	reaction 2
A	endothermic	endothermic
B	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

[2007 M/J (14)]

22.

The standard enthalpy changes of formation of HCl and HI are $-92\,kJ\,mol^{-1}$ and $+26\,kJ\,mol^{-1}$ respectively.

Which statement is **most** important in explaining this difference?

A Chlorine is more electronegative than iodine.

B The activation energy for the H_2/Cl_2 reaction is much less than that for the H_2/I_2 reaction.

C The bond energy of HI is smaller than the bond energy of HCl.

D The bond energy of I_2 is smaller than the bond energy of Cl_2.

[2007 M/J (16)]

23.

Which equation represents the standard enthalpy change of atomisation of bromine?

A $Br_2(l) \rightarrow 2Br(g)$

B $Br_2(g) \rightarrow 2Br(g)$

C $\frac{1}{2}Br_2(l) \rightarrow Br(g)$

D $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

[2007 O/N (8)]

24.

For which equation does the enthalpy change correspond to the enthalpy change of atomisation of iodine?

A $\frac{1}{2}I_2(s) \rightarrow I(s)$

B $\frac{1}{2}I_2(s) \rightarrow I(g)$

C $I_2(g) \rightarrow 2I(g)$

D $I_2(s) \rightarrow 2I(g)$

[2008 M/J (9)]

25.

Titanium occurs naturally as the mineral rutile, TiO_2. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

$$TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g)$$

The standard enthalpy changes of formation of $TiO_2(s)$ and $CO(g)$ are $-940\ kJ\ mol^{-1}$ and $-110\ kJ\ mol^{-1}$ respectively.

What is the standard enthalpy change of this reaction?

A $-830\ kJ\ mol^{-1}$

B $-720\ kJ\ mol^{-1}$

C $+720\ kJ\ mol^{-1}$

D $+830\ kJ\ mol^{-1}$

[2008 M/J (10)]

26.

Red lead oxide, Pb_3O_4, is used in metal priming paints. It can be made by heating PbO in air.

$$6PbO(s) + O_2(g) \rightarrow 2Pb_3O_4(s)$$

Which two values are needed to calculate the enthalpy change for this reaction?

A enthalpy change of combustion of lead and enthalpy change of formation of Pb_3O_4

B enthalpy change of combustion of PbO and enthalpy change of formation of Pb_3O_4

C enthalpy change of formation of PbO and enthalpy change of atomisation of O_2

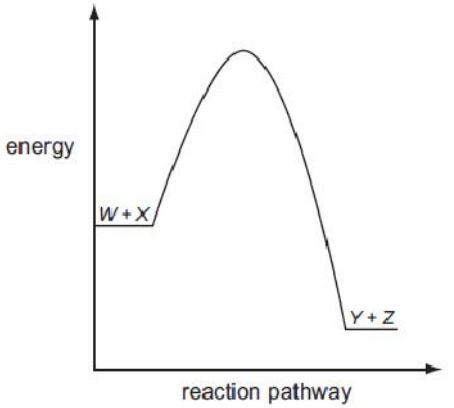
D enthalpy change of formation of PbO and enthalpy change of formation of Pb_3O_4

[2008 O/N (8)]

27.

The diagram represents the reaction pathway for the following reaction.

$$W(g) + X(g) \rightarrow Y(g) + Z(g)$$



What statement can be made about the reverse reaction, $Y(g) + Z(g) \rightarrow W(g) + X(g)$?

A It will have a larger activation energy and a positive ΔH.

B It will have a larger activation energy and a negative ΔH.

C It will have a smaller activation energy and a positive ΔH.

D It will have a smaller activation energy and a negative ΔH.

[2008 O/N (9)]

28.

Hydrogen peroxide slowly decomposes into water and oxygen. The enthalpy change of reaction can be calculated using standard enthalpies of formation.

$\Delta H_f^{\ominus}$(hydrogen peroxide(l)) = –187.8 kJ mol^{-1}

$\Delta H_f^{\ominus}$(water(l)) = –285.8 kJ mol^{-1}

Using a Hess cycle, what is the enthalpy change of reaction for this decomposition?

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

A +98 kJ mol^{-1}

B –98 kJ mol^{-1}

C –196 kJ mol^{-1}

D –947.2 kJ mol^{-1}

[2009 M/J (8)]

29.

For which reactions does the value of $\Delta H^{\ominus}$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

1 $C(s) + O_2(g) \rightarrow CO_2(g)$

2 $2C(s) + O_2(g) \rightarrow 2CO(g)$

3 $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

[2009 M/J (33)]

30.

The first stage in the industrial production of nitric acid from ammonia can be represented by the following equation.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Using the following standard enthalpy change of formation data, what is the value of the standard enthalpy change, $\Delta H^{\ominus}$, for this reaction?

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$NH_3(g)$	–46.1
$NO(g)$	+90.3
$H_2O(g)$	–241.8

A +905.2 kJ mol^{-1}

B –105.4 kJ mol^{-1}

C –905.2 kJ mol^{-1}

D –1274.0 kJ mol^{-1}

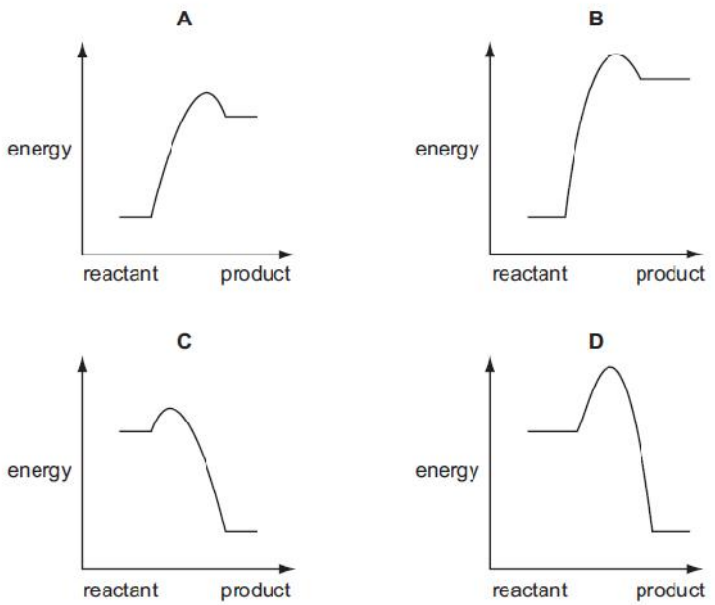
[2009 O/N-11 (6)]

31.

Four reactions of the type shown are studied at the same temperature.

$$X(g) + Y(g) \rightarrow Z(g)$$

Which is the correct reaction pathway diagram for the reaction that would proceed **most** rapidly and with the **highest** yield?



[2009 O/N-11 (10)]

32.

Given the following enthalpy changes,

$$I_2(g) + 3Cl_2(g) \rightarrow 2ICl_3(s) \qquad \Delta H^{\ominus} = -214\,kJ\,mol^{-1}$$

$$I_2(s) \rightarrow I_2(g) \qquad \Delta H^{\ominus} = +38\,kJ\,mol^{-1}$$

What is the standard enthalpy change of formation of iodine trichloride, $ICl_3(s)$?

A $+176\,kJ\,mol^{-1}$

B $-88\,kJ\,mol^{-1}$

C $-176\,kJ\,mol^{-1}$

D $-214\,kJ\,mol^{-1}$

[2010 M/J-11 (5)]

33.

Some bond energy values are listed below.

bond	bond energy / kJ mol^{-1}
C–H	410
C–Cl	340
Cl–Cl	244
Br–Br	193

These bond energy values relate to the following four reactions.

P $Br_2 \rightarrow 2Br$

Q $2Cl \rightarrow Cl_2$

R $CH_3 + Cl \rightarrow CH_3Cl$

S $CH_4 \rightarrow CH_3 + H$

What is the order of enthalpy changes of these reactions from most negative to most positive?

A P → Q → R → S

B Q → R → S → P

C R → Q → P → S

D S → P → Q → R

[2010 M/J-13 (5)]

34.

Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^- \qquad \Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^- \qquad \Delta H = X$

$Na(s) \rightarrow Na(g) \qquad \Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^- \qquad \Delta H = Z$

What is the second ionisation energy of sodium?

A 2W **B** X – W **C** Y – W **D** Z – Y

[2010 O/N-11 (3)]

35.

Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for this reaction?

compound	$\Delta H_c^{\ominus}$/kJ mol^{-1}
carbon	–394
hydrogen	–286
butane	–2877

A –5883 kJ mol^{-1}

B –129 kJ mol^{-1}

C +129 kJ mol^{-1}

D +2197 kJ mol^{-1}

[2010 O/N-11 (8)]

36.

In a calorimetric experiment 1.60 g of a fuel is burnt. 45 % of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

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

A 25 200 J **B** 56 000 J **C** 89 600 J **D** 143 360 J

[2010 O/N-11 (9)]

37.

Which equation represents the change corresponding to the enthalpy change of atomisation of iodine?

A $\frac{1}{2} I_2(g) \rightarrow I(g)$

B $I_2(g) \rightarrow 2I(g)$

C $\frac{1}{2} I_2(s) \rightarrow I(g)$

D $I_2(s) \rightarrow 2I(g)$

[2010 O/N-11 (11)]

38.

Methanol may be prepared by the reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

The relevant average bond energies are given below.

E(C≡O)	1077 kJ mol^{-1}
E(C–O)	360 kJ mol^{-1}
E(C–H)	410 kJ mol^{-1}
E(H–H)	436 kJ mol^{-1}
E(O–H)	460 kJ mol^{-1}

What is the enthalpy change of this reaction?

A –537 kJ mol^{-1}

B –101 kJ mol^{-1}

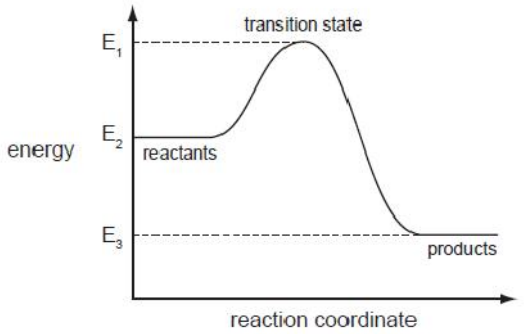
C +101 kJ mol^{-1}

D +537 kJ mol^{-1}

[2010 O/N-12 (4)]

39.

The reaction pathway diagram below illustrates the energies of reactants, products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_1 - E_3$ **C** $E_2 - E_3$ **D** $(E_1 - E_2) - (E_2 - E_3)$

[2010 O/N-12 (6)]

40.

Use of the Data Booklet is relevant to this question.

The enthalpy change of formation, ΔH_f, of hydrated calcium ions is the enthalpy change of the following reaction.

$$Ca(s) + aq - 2e^- \rightarrow Ca^{2+}(aq)$$

The following enthalpy changes are **not** quoted in the *Data Booklet*.

$$Ca(s) \rightarrow Ca(g) \qquad \Delta H_a = 177\,kJ\,mol^{-1}$$
$$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq) \qquad \Delta H_{hyd} = -1565\,kJ\,mol^{-1}$$

What is the enthalpy change of formation of hydrated calcium ions?

A $-1388\,kJ\,mol^{-1}$

B $-798\,kJ\,mol^{-1}$

C $-238\,kJ\,mol^{-1}$

D $+352\,kJ\,mol^{-1}$

[2010 O/N-12 (8)]

41.

The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.

$$2X(g) + 6H(g) \rightarrow X_2H_6(g) \qquad \Delta H = -2775\,kJ\,mol^{-1}$$

The bond energy of an X–H bond is $395\,kJ\,mol^{-1}$.

What is the bond energy of an X–X bond?

A $-405.0\,kJ\,mol^{-1}$

B $-202.5\,kJ\,mol^{-1}$

C $+202.5\,kJ\,mol^{-1}$

D $+405.0\,kJ\,mol^{-1}$

[2011 M/J-11 (8)]

42.

Titanium occurs naturally as the mineral rutile, TiO_2. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

$$TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g)$$

The standard enthalpy changes of formation of $TiO_2(s)$ and $CO(g)$ are $-940\,kJ\,mol^{-1}$ and $-110\,kJ\,mol^{-1}$ respectively.

What is the standard enthalpy change of this reaction?

A $-830\,kJ\,mol^{-1}$

B $-720\,kJ\,mol^{-1}$

C $+720\,kJ\,mol^{-1}$

D $+830\,kJ\,mol^{-1}$

[2011 M/J-12 (7)]

43.

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

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

[2011 M/J-12 (8)]

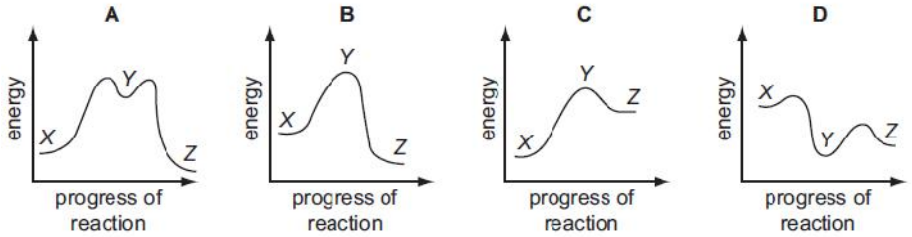
44.

In the conversion of compound *X* into compound *Z*, it was found that the reaction proceeded by way of compound *Y*, which could be isolated. The following steps were involved.

$X \rightarrow Y$; ΔH, positive

$Y \rightarrow Z$; ΔH, negative

Which reaction profile fits these data?



[2011 M/J-12 (9)]

45.

The standard enthalpy change for the reaction

$2NF_3(g) \rightarrow 2N(g) + 6F(g)$ is $\Delta H^{\ominus} = +1668\,kJ$

What is the bond energy of the N–F bond?

A $-556\,kJ\,mol^{-1}$

B $-278\,kJ\,mol^{-1}$

C $+278\,kJ\,mol^{-1}$

D $+556\,kJ\,mol^{-1}$

[2011 O/N-11 (6)]

46.

Hess's Law can be used to calculate the average C-H bond energy in methane.

$\Delta H^{\ominus}_{at}$ = standard enthalpy change of atomisation

$\Delta H^{\ominus}_{f}$ = standard enthalpy change of formation

$\Delta H^{\ominus}_{c}$ = standard enthalpy change of combustion

Which data values are needed in order to perform the calculation?

A $\Delta H^{\ominus}_{at}$ (C), $\Delta H^{\ominus}_{at}$ (H), $\Delta H^{\ominus}_{f}$ (CH_4)

B $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{c}$ (CH_4)

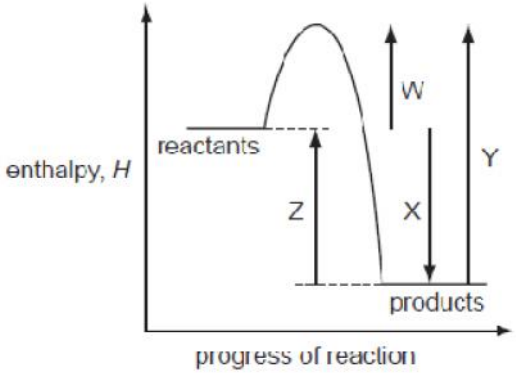
C $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{f}$ (CH_4)

D $\Delta H^{\ominus}_{f}$ (CH_4) only, as $\Delta H^{\ominus}_{f}$ (C), and $\Delta H^{\ominus}_{f}$ (H_2), are defined as zero

[2011 O/N-12 (10)]

47.

An energy profile diagram is shown.



What do the labels on the diagram represent?

1 W = ΔH of the forward reaction, Y = E_a of the backward reaction

2 Z = ΔH of the backward reaction, Y = E_a of the backward reaction

3 X = ΔH of the forward reaction, W = E_a of the forward reaction

[2011 O/N-12 (32)]

48.

The equation for a reaction is shown.

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)\ ;\ \Delta H = x\ \text{kJ mol}^{-1}$$

Which pair of descriptions is fully correct for this reaction?

	type(s) of enthalpy change	value of *x*
A	formation only	positive
B	formation only	negative
C	combustion, formation	positive
D	combustion, formation	negative

[2012 M/J-11 (3)]

49.

Propanone has the molecular formula C_3H_6O.

The enthalpy change of combustion of hydrogen is $-286\ \text{kJ mol}^{-1}$.
The enthalpy change of combustion of carbon is $-394\ \text{kJ mol}^{-1}$.
The enthalpy change of combustion of propanone is $-1786\ \text{kJ mol}^{-1}$.

Using this information, what is the enthalpy change of formation of propanone?

A $-1106\ \text{kJ mol}^{-1}$

B $-540\ \text{kJ mol}^{-1}$

C $-254\ \text{kJ mol}^{-1}$

D $+1106\ \text{kJ mol}^{-1}$

[2012 M/J-11 (7)]

50.

Red lead oxide, Pb_3O_4, is used in metal priming paints. It can be made by heating PbO in air.

$$6PbO(s) + O_2(g) \rightarrow 2Pb_3O_4(s)$$

Which two values are needed to calculate the enthalpy change for this reaction?

A enthalpy change of atomisation of O_2 and enthalpy change of formation of Pb_3O_4

B enthalpy change of formation of O_2 and enthalpy change of formation of Pb_3O_4

C enthalpy change of formation of PbO and enthalpy change of atomisation of O_2

D enthalpy change of formation of PbO and enthalpy change of formation of Pb_3O_4

[2012 M/J-12 (12)]

51.

Use of the Data Booklet is relevant to this question.

A reaction which causes the presence of oxides of nitrogen in car exhausts is the formation of NO.

$$N_2 + O_2 \rightarrow 2NO \qquad \Delta H = +180\ \text{kJ mol}^{-1}$$

What is the bond energy in kJ mol^{-1} of the bond between the atoms in NO?

A 655 **B** 835 **C** 1310 **D** 1670

[2012 O/N-11 (4)]

52.

In the table below,

- '+' means that this type of standard enthalpy change can **only** have positive values,
- '–' means that this type of standard enthalpy change can **only** have negative values,
- '+/–' means that **either** positive **or** negative values are possible.

Which row is correct?

	atomisation	formation	solution
A	+	+	+/–
B	+	+/–	+/–
C	–	+/–	–
D	–	–	+

[2012 O/N-11 (5)]

53.

A student calculated the standard enthalpy change of formation of ethane, C_2H_6, using a method based on standard enthalpy changes of combustion.

He used correct values for the standard enthalpy change of combustion of ethane ($-1560\ kJ\ mol^{-1}$) and hydrogen ($-286\ kJ\ mol^{-1}$) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was $-158\ kJ\ mol^{-1}$.

What did he use for the standard enthalpy change of combustion of carbon?

A $-1432\ kJ\ mol^{-1}$

B $-860\ kJ\ mol^{-1}$

C $-430\ kJ\ mol^{-1}$

D $-272\ kJ\ mol^{-1}$

[2012 O/N-11 (10)]

54.

Which process could be used to calculate the bond energy for the covalent bond X-Y by dividing its ΔH by n?

A $XY_n(g) \rightarrow X(g) + nY(g)$

B $2XY_n(g) \rightarrow 2XY_{n-1}(g) + Y_2(g)$

C $Y(g) + XY_{n-1}(g) \rightarrow XY_n(g)$

D $nXY(g) \rightarrow nX(g) + \frac{n}{2}Y_2(g)$

[2012 O/N-11 (11)]

55.

Ethyne, C_2H_2, completely combusts, as shown in the equation.

$$H{-}C{\equiv}C{-}H + 2\tfrac{1}{2}O{=}O \rightarrow H_2O + 2CO_2$$

Using the average bond enthalpies in the table, what is the enthalpy change of combustion of ethyne?

bond	average bond enthalpy / kJ mol^{-1}
C—H	410
C≡C	840
O=O	496
C=O	740
O—H	460
C—O	360

A $-980\ kJ\ mol^{-1}$ **B** $-540\ kJ\ mol^{-1}$ **C** $+540\ kJ\ mol^{-1}$ **D** $+980\ kJ\ mol^{-1}$

[2012 O/N-13 (5)]

56.

The enthalpy change of the neutralisation given below is –114 kJ mol^{-1}.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

By using this information, what is the most likely value for the enthalpy change of the following neutralisation?

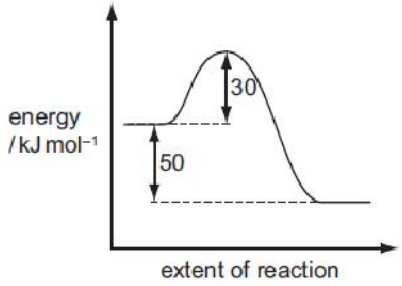
$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

A –57 kJ mol^{-1} **B** –76 kJ mol^{-1} **C** –114 kJ mol^{-1} **D** –228 kJ mol^{-1}

[2012 O/N-13 (10)]

57.

The reaction pathway for a reversible reaction is shown below.



Which statement is correct?

A The activation energy of the reverse reaction is +80 kJ mol^{-1}.

B The enthalpy change for the forward reaction is +30 kJ mol^{-1}.

C The enthalpy change for the forward reaction is +50 kJ mol^{-1}.

D The enthalpy change for the reverse reaction is +30 kJ mol^{-1}.

[2013 M/J-11 (7)]

58.

Use of the Data Booklet is relevant to this question.

This question should be answered using bond enthalpy data. The equation for the complete combustion of methane is given below.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

What is the enthalpy change of combustion of methane?

A –1530 kJ mol^{-1}

B –1184 kJ mol^{-1}

C –770 kJ mol^{-1}

D –688 kJ mol^{-1}

[2013 M/J-11 (12)]

59.

Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

What is the second ionisation energy of sodium?

A X **B** X – W **C** Y – W **D** Z – Y

[2013 M/J-12 (2)]

60.

Use of the Data Booklet is relevant to this question.

A student mixed 25 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution with 25 cm^3 of 0.10 mol dm^{-3} hydrochloric acid and noted a temperature rise of 2.5 °C.

What is the enthalpy change of the reaction per mole of NaOH?

A $-209\ kJ\ mol^{-1}$

B $-104.5\ kJ\ mol^{-1}$

C $-209\ J\ mol^{-1}$

D $-522.5\ J\ mol^{-1}$

[2013 M/J-12 (10)]

61.

Which energy change corresponds to the enthalpy change of atomisation of hydrogen at 298 K?

A the bond energy of a H–H bond

B half the bond energy of a H–H bond

C minus half the bond energy of a H–H bond

D minus the bond energy of a H–H bond

[2013 M/J-12 (11)]

62.

Propanone has molecular formula C_3H_6O.

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

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

The enthalpy change of formation of propanone is $-254\ kJ\ mol^{-1}$.

Using this information, what is the enthalpy change of combustion of propanone?

A $-2644\ kJ\ mol^{-1}$

B $-2294\ kJ\ mol^{-1}$

C $-1786\ kJ\ mol^{-1}$

D $-426\ kJ\ mol^{-1}$

[2013 M/J-12 (12)]

63.

Use of the Data Booklet is relevant to this question.

This question should be answered using bond enthalpy data. The equation for the complete combustion of methanal is given below.

$$H_2C{=}O + O_2 \rightarrow CO_2 + H_2O$$

What is the enthalpy change of combustion of methanal?

A $+416\ kJ\ mol^{-1}$

B $+396\ kJ\ mol^{-1}$

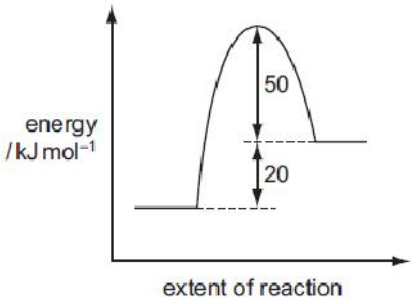
C $-344\ kJ\ mol^{-1}$

D $-690\ kJ\ mol^{-1}$

[2013 M/J-13 (11)]

64.

The reaction pathway for a reversible reaction is shown below.



Which statements are correct?

1 The enthalpy change for the backward reaction is $-20\ kJ\ mol^{-1}$.

2 The forward reaction is endothermic.

3 The activation energy for the forward reaction is $+70\ kJ\ mol^{-1}$.

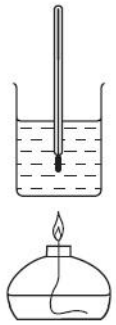
[2013 M/J-13 (33)]

65.

Use of the Data Booklet is relevant to this question.

A student carried out an experiment to determine the enthalpy change for the combustion of methanol.

The following results were obtained by the student.



start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

How much of the heat energy produced by the burning of methanol went into the water?

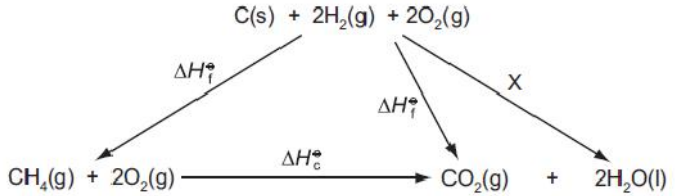
A 209 J **B** 13 794 J **C** 20 691 J **D** 22 154 J

[2013 O/N-11 (11)]

66.

Enthalpy changes that are difficult to measure directly can often be determined using Hess' Law to construct an enthalpy cycle.

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



A – 4 × the enthalpy of combustion of hydrogen

B + 4 × the enthalpy of combustion of hydrogen

C – 2 × the enthalpy of formation of water

D + 2 × the enthalpy of formation of water

[2014 M/J-11 (3)]

67.

A student mixed 25.0 cm^3 of 0.350 mol dm^{-3} sodium hydroxide solution with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature rose by 2.50 °C. Assume that no heat was lost to the surroundings.

The final mixture had a specific heat capacity of 4.20 J cm^{-3} K^{-1}.

What is the molar enthalpy change for the reaction?

A –150 kJ mol^{-1}

B –60.0 kJ mol^{-1}

C –30.0 kJ mol^{-1}

D –0.150 kJ mol^{-1}

[2014 M/J-11 (5)]

68.

Use of the Data Booklet is relevant to this question.

When the liquid N_2F_4 is heated, it decomposes into a single product, X.

Which statements are correct?

1 N – F bonds are broken during this decomposition.

2 The enthalpy change when N_2F_4 decomposes into X is approximately +160 kJ mol^{-1}.

3 Molecules of X are non-linear.

[2014 M/J-11 (31)]

69.

The enthalpy change of formation of carbon dioxide is –394 kJ mol^{-1}.
The enthalpy change of formation of water is –286 kJ mol^{-1}.
The enthalpy change of formation of methane is –74 kJ mol^{-1}.

What is the enthalpy change of combustion of methane?

A –892 kJ mol^{-1}

B –606 kJ mol^{-1}

C +606 kJ mol^{-1}

D +892 kJ mol^{-1}

[2014 M/J-12 (3)]

70.

Which equation represents the standard enthalpy change of formation of ethanol, C_2H_5OH?

A $2C(g) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

B $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

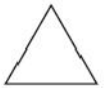
C $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$

D $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(l)$

[2014 M/J-12 (8)]

71.

The diagram shows the skeletal formula of cyclopropane.



The enthalpy change of formation of cyclopropane is +53.3 kJ mol^{-1} and the enthalpy change of atomisation of graphite is +717 kJ mol^{-1}.

The bond enthalpy of H – H is 436 kJ mol^{-1} and of C – H is 410 kJ mol^{-1}.

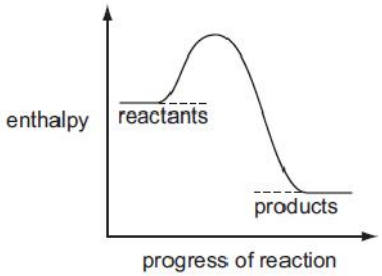
What value for the average bond enthalpy of the C – C bond in cyclopropane can be calculated from this data?

A 187 kJ mol^{-1} B 315 kJ mol^{-1} C 351 kJ mol^{-1} D 946 kJ mol^{-1}

[2014 M/J-12 (11)]

72.

A reaction pathway diagram is shown.



Which enthalpy change could the diagram **not** apply to?

A enthalpy of atomisation

B enthalpy of combustion

C enthalpy of formation

D enthalpy of neutralisation

[2014 M/J-13 (3)]

73.

The enthalpy change of formation of $Mn(NO_3)_2(s)$ is $-696\,kJ\,mol^{-1}$.
The enthalpy change of formation of $MnO_2(s)$ is $-520\,kJ\,mol^{-1}$.
The enthalpy change of formation of $NO_2(g)$ is $+33\,kJ\,mol^{-1}$.

On heating, $Mn(NO_3)_2$ decomposes into MnO_2 and NO_2.

$$Mn(NO_3)_2(s) \rightarrow MnO_2(s) + 2NO_2(g)$$

What is the value of the standard enthalpy change of this reaction?

A $-242\,kJ\,mol^{-1}$

B $-209\,kJ\,mol^{-1}$

C $+209\,kJ\,mol^{-1}$

D $+242\,kJ\,mol^{-1}$

[2014 M/J-13 (9)]

74.

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

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

[2014 M/J-13 (11)]

75.

Ethanol is increasingly being used as a fuel for cars.

The standard enthalpy change of formation of carbon dioxide is $-393\,kJ\,mol^{-1}$.
The standard enthalpy change of formation of water is $-286\,kJ\,mol^{-1}$.
The standard enthalpy change of formation of ethanol is $-277\,kJ\,mol^{-1}$.

What is the standard enthalpy change of combustion of ethanol?

A $-1921\,kJ\,mol^{-1}$

B $-1367\,kJ\,mol^{-1}$

C $-956\,kJ\,mol^{-1}$

D $-402\,kJ\,mol^{-1}$

[2014 O/N-11 (3)]

76.

In an experiment to calculate the enthalpy change of combustion of a fuel, 1.5 g (0.0326 mol) of the fuel was used to heat 200 g of water. The temperature of the water rose from 25 °C to 55 °C. The specific heat capacity of water is $4.18\,J\,g^{-1}\,K^{-1}$.

There is significant heat loss in this experiment. Therefore, the experimental value for the enthalpy change of combustion, ΔH_c, of the fuel will be different from the theoretical value.

Using the information above, what is the experimental value for the enthalpy change of combustion, ΔH_c, of the fuel?

A $-1410\,kJ\,mol^{-1}$

B $-769\,kJ\,mol^{-1}$

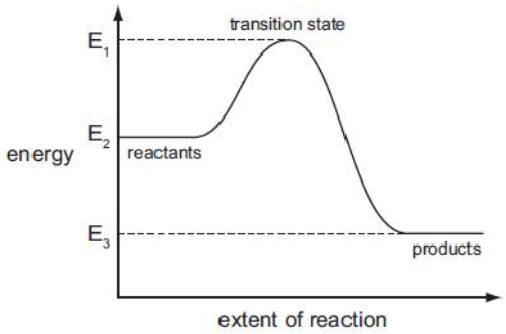
C $-30.7\,kJ\,mol^{-1}$

D $-16.7\,kJ\,mol^{-1}$

[2014 O/N-11 (7)]

77.

The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_2 - E_1$ **C** $E_2 - E_3$ **D** $E_3 - E_2$

[2014 O/N-11 (8)]

78.

Use of the Data Booklet is relevant to this question.

The bond energy of the Br–O bond is 235 kJ mol^{-1}.

Which reactions are exothermic?

1 $OH\bullet + HBr \rightarrow H_2 + BrO\bullet$

2 $OH\bullet + HBr \rightarrow H_2O + Br\bullet$

3 $H\bullet + HBr \rightarrow H_2 + Br\bullet$

[2014 O/N-11 (32)]

79.

Hydrogen sulfide, H_2S, is released from volcanoes. It reacts with oxygen in the air to form sulfur dioxide.

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$$

$\Delta H_f^{\ominus}[H_2S(g)] = -21\ kJ\ mol^{-1}$

$\Delta H_f^{\ominus}[H_2O(l)] = -286\ kJ\ mol^{-1}$

$\Delta H_f^{\ominus}[SO_2(g)] = -297\ kJ\ mol^{-1}$

What is the standard enthalpy change of this reaction?

A $-1208\ kJ\ mol^{-1}$

B $-1124\ kJ\ mol^{-1}$

C $-562\ kJ\ mol^{-1}$

D $-541\ kJ\ mol^{-1}$

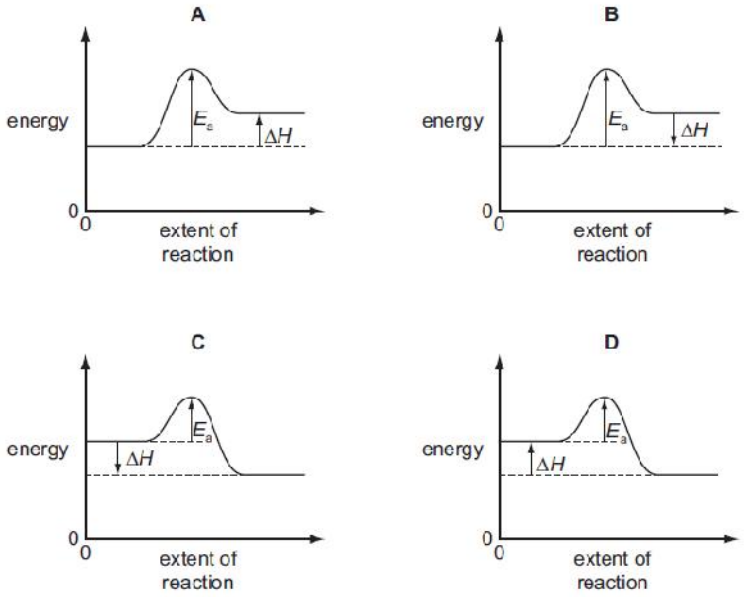
[2014 O/N-13 (5)]

80.

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

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \qquad \Delta H = +66\ kJ\ mol^{-1}$$

Which labelled diagram correctly represents the energy profile for this reaction?



[2014 O/N-13 (10)]

81.

Use of the Data Booklet is relevant to this question.

When 0.47 g of a hydrocarbon was completely burnt in air, the energy released heated 200 g of water from 23.7 °C to 41.0 °C.

What was the amount of energy absorbed by the water?

A $0.47 \times 4.18 \times 17.3\ J$

B $0.47 \times 4.18 \times (273 + 17.3)\ J$

C $200 \times 4.18 \times 17.3\ J$

D $200 \times 4.18 \times (273 + 17.3)\ J$

[2014 O/N-13 (11)]

82.

Which names can be applied to the enthalpy change of the reaction shown?

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)$$

1 enthalpy change of formation

2 enthalpy change of combustion

3 enthalpy change of hydration

[2014 O/N-13 (34)]