Chemical energetics – 2021 AS

1. Nov/2021/Paper_11/No.7

In order to determine the enthalpy of neutralisation of a strong acid and a strong alkali, 25.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 25.0 cm^3 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 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 50.0 cm^3 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

2. Nov/2021/Paper_11/No.8

Which equation represents 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 $I_2(s) \rightarrow 2I(g)$

3. Nov/2021/Paper_11/No.9

Zinc atoms can be oxidised to Zn^{2+} ions by dichromate(VI) ions in acid solution. Chromium is reduced to Cr^{3+} in this reaction.

Which equation is correct?

A $Cr_2O_7^{2-} + Zn + 14H^+ \rightarrow 2Cr^{3+} + Zn^{2+} + 7H_2O$

B $Cr_2O_7^{2-} + Zn + 14H^+ \rightarrow 2Cr^{3+} + 3Zn^{2+} + 7H_2O$

C $Cr_2O_7^{2-} + 3Zn + 14H^+ \rightarrow 2Cr^{3+} + 3Zn^{2+} + 7H_2O$

D $2Cr_2O_7^{2-} + 3Zn + 14H^+ \rightarrow 2Cr^{3+} + 3Zn^{2+} + 7H_2O$

4. Nov/2021/Paper_11/No.17

Z is a compound of sodium, chlorine and oxygen.

It contains 45.1% by mass of oxygen.

Z is prepared by reacting sodium hydroxide with chlorine.

Which row shows the conditions used for the reaction and the oxidation state of chlorine in Z?

	reaction conditions	oxidation state of Cl in Z
A	cold dilute NaOH	+1
B	cold dilute NaOH	+5
C	hot concentrated NaOH	+1
D	hot concentrated NaOH	+5

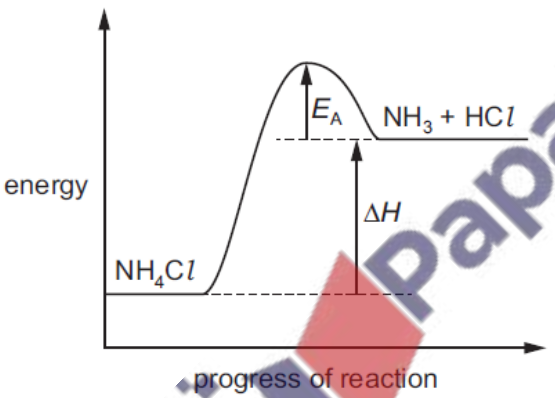
5. Nov/2021/Paper_12/No.9

The equation for the formation of ammonium chloride is shown.

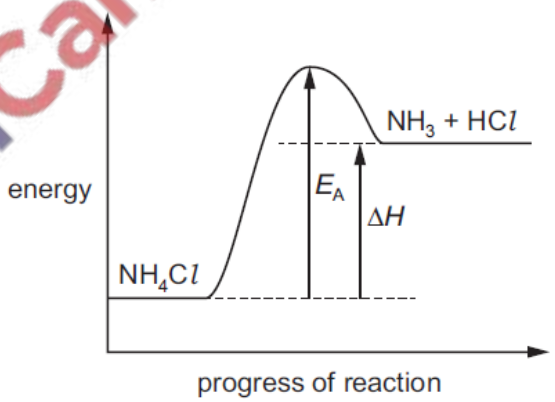
$$NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s) \qquad \Delta H = -314\,kJ\,mol^{-1}$$

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

A



B



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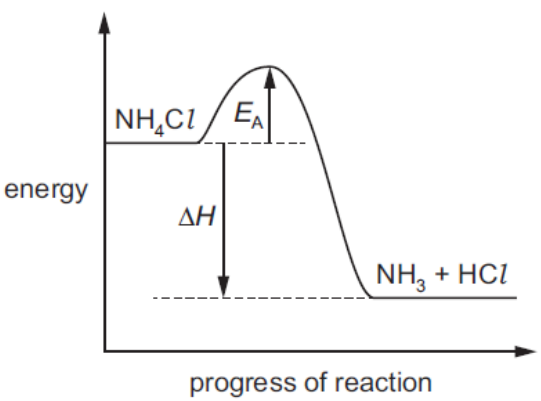

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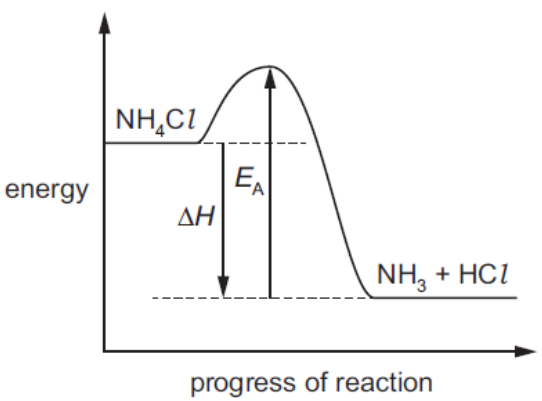


6. Nov/2021/Paper_12/No.10

In a catalytic converter in the exhaust system of a car, carbon monoxide is oxidised to carbon dioxide, and nitrogen monoxide is reduced to nitrogen.

What are the changes in oxidation number of carbon and nitrogen in these two processes?

	carbon	nitrogen
A	–2	+2
B	–1	+1
C	+1	–1
D	+2	–2

7. Nov/2021/Paper_12/No.11

NO and NO_2 are both present in the lower atmosphere as pollutants.

The reaction sequence shows the production of ozone from oxygen in the lower atmosphere.

This sequence repeats many times.

$$NO_2(g) \rightarrow NO(g) + O(g)$$

$$NO(g) + \tfrac{1}{2}O_2(g) \rightarrow NO_2(g)$$

$$O_2(g) + O(g) \rightarrow O_3(g)$$

Which statement about this reaction sequence is correct?

A NO is acting as a catalyst, but NO_2 is not acting as a catalyst.

B NO_2 is acting as a catalyst, but NO is not acting as a catalyst.

C Neither NO nor NO_2 are acting as catalysts.

D Both NO and NO_2 are acting as catalysts.

8. Nov/2021/Paper_12/No.33

Which reactions are redox reactions?

1 $Mg + 2HCl \rightarrow MgCl_2 + H_2$

2 $2K_2CrO_4 + 2H^+ \rightarrow K_2Cr_2O_7 + 2K^+ + H_2O$

3 $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

9. Nov/2021/Paper_13/No.8

Which equation represents 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 $I_2(s) \rightarrow 2I(g)$

10. Nov/2021/Paper_21/No.1(b)

(b) The enthalpy change of combustion of $CS_2(l)$ is represented by the following equation.

$$CS_2(l) + 3O_2(g) \xrightarrow{\Delta H_c} CO_2(g) + 2SO_2(g)$$

(i) Define *enthalpy change of combustion*.

.....

.....

..... [2]

(ii) The table shows the enthalpy changes of formation of $CS_2(l)$, $CO_2(g)$ and $SO_2(g)$.

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
$CS_2(l)$	+89.7
$CO_2(g)$	–394
$SO_2(g)$	–297

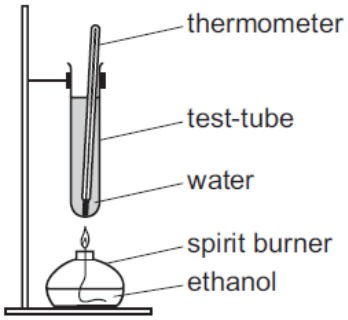
Use the data in the table to calculate the enthalpy change of combustion, ΔH_c, of $CS_2(l)$, in kJ mol^{-1}.

Show your working.

ΔH_c of $CS_2(l)$ = ... kJ mol^{-1} [2]

11. March/2021/Paper_12/No/.7

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



The data collected are shown.

mass of water = Wg

mass of ethanol burned = Xg

temperature rise = Y°C

molar mass of ethanol = Zg mol^{-1}

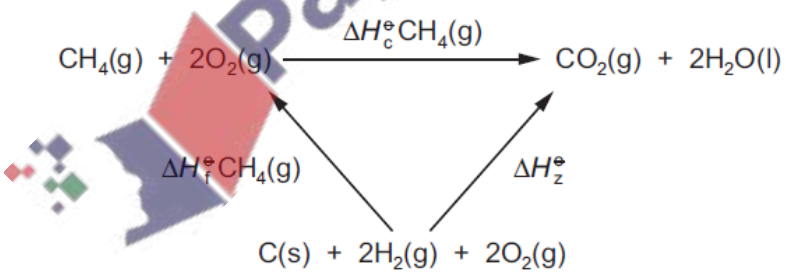
specific heat capacity of water = 4.2 J K^{-1} g^{-1}

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

12. March/2021/Paper_12/No/.32

An energy cycle for the combustion of methane is shown.



Which expressions can be used to calculate the energy change, $\Delta H_z^{\ominus}$?

1 $\Delta H_f^{\ominus}CH_4(g) + \Delta H_c^{\ominus}CH_4(g)$

2 $\Delta H_c^{\ominus}C(s) + 2\Delta H_c^{\ominus}H_2(g)$

3 $\Delta H_c^{\ominus}CO(g) + 2\Delta H_c^{\ominus}H_2(g)$

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.

13. June/2021/Paper_11/No.4

$\Delta H_1^\ominus$ is the standard enthalpy of formation of methane.

$\Delta H_2^\ominus$ is the standard enthalpy of combustion of carbon.

$\Delta H_3^\ominus$ is the standard enthalpy of combustion of hydrogen.

$$CH_4(g) + 2O_2(g) \xrightarrow{\Delta H_c^\ominus} CO_2(g) + 2H_2O(l)$$

Which expression is equivalent to $\Delta H_c^\ominus$?

A $\Delta H_1^\ominus - \Delta H_2^\ominus + \Delta H_3^\ominus$

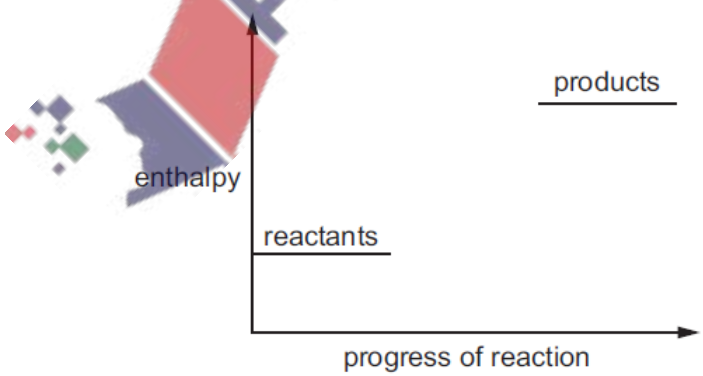
B $\Delta H_1^\ominus - 2\Delta H_3^\ominus - \Delta H_2^\ominus$

C $\Delta H_2^\ominus - \Delta H_3^\ominus + \Delta H_1^\ominus$

D $\Delta H_2^\ominus + 2\Delta H_3^\ominus - \Delta H_1^\ominus$

14. June/2021/Paper_11/No.32

The diagram shows an incomplete energy profile diagram for a reaction.



Which reactions could this diagram refer to?

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

2 $H_2(g) \rightarrow 2H(g)$

3 $Cl^-(aq) \rightarrow Cl^-(g) + aq$

15. June/2021/Paper_12/No.8

Nitrogen and oxygen can react together to form nitrogen monoxide, NO.

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

What is the bond energy of the bond between the atoms in NO?

A $630\,kJ\,mol^{-1}$ **B** $810\,kJ\,mol^{-1}$ **C** $1260\,kJ\,mol^{-1}$ **D** $1620\,kJ\,mol^{-1}$

16. June/2021/Paper_13/No.7

Using the information in the table, what is the enthalpy change, q, for the reaction described?

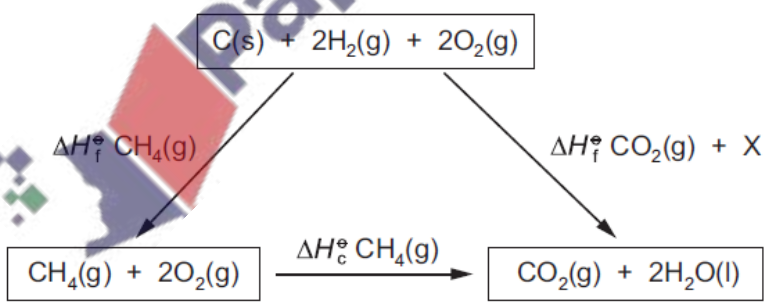
$$Cs^+(g) + Br^-(g) \rightarrow CsBr(s) \qquad \Delta H = q\,kJ\,mol^{-1}$$

standard enthalpy change	value / $kJ\,mol^{-1}$
$\Delta H^{\ominus}_{sol}$ CsBr(s)	+25.9
$\Delta H^{\ominus}_{hyd}$ $Cs^+(g)$	–276
$\Delta H^{\ominus}_{hyd}$ $Br^-(g)$	–335

A –636.9 **B** –585.1 **C** +585.1 **D** +636.9

17. June/2021/Paper_13/No.8

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

18. June/2021/Paper_13/No.11

Nitric acid is produced by oxidising ammonia. The first step is to react ammonia with oxygen in the presence of a catalyst to form nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta H = -1636\,kJ\,mol^{-1}$$

Which set of conditions will produce the greatest yield of nitrogen monoxide at equilibrium?

	temperature	pressure
A	high	high
B	high	low
C	low	high
D	low	low

19. June/2021/Paper_21/No.4

Aqueous bromine reacts with methanoic acid to form hydrogen bromide and carbon dioxide gas.

$$Br_2(aq) + HCO_2H(aq) \rightarrow 2HBr(aq) + CO_2(g)$$

The table shows the oxidation numbers of bromine and carbon in the species involved in this reaction.

	Br in Br_2	C in HCO_2H	Br in HBr	C in CO_2
oxidation number	0	+2	–1	+4

(a) Identify the oxidising agent in this reaction. Explain your reasoning with reference to oxidation numbers.

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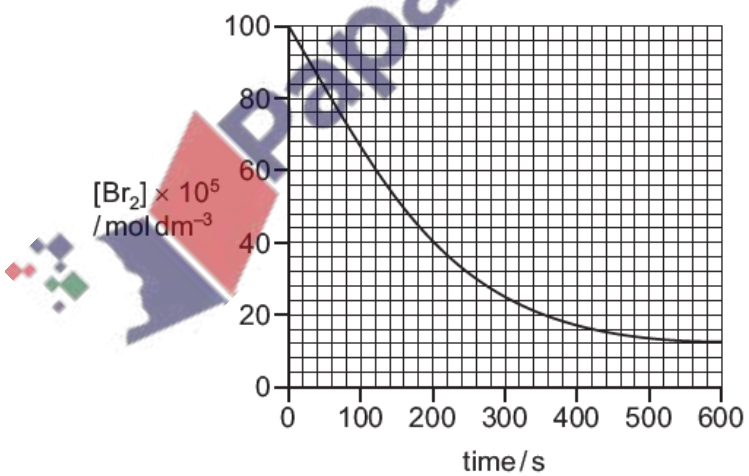
..... [1]

(b) Suggest one change you would observe, ignoring temperature changes, when bromine reacts with methanoic acid.

..... [1]

(c) This reaction can be followed by measuring the concentration of bromine present in the mixture at regular time intervals.

The graph shows the change in concentration of bromine against time in a reaction carried out at 20 °C.



(i) Use the graph to calculate the average rate of reaction at 20 °C during the first 600 s. State the units of this rate of reaction.

average rate of reaction ..... units .....

[2]

The experiment is repeated at a temperature of 40 °C. This relatively small increase in temperature produces a large increase in reaction rate.

(ii) Sketch a graph, on the same axes, to show the expected results when repeating the experiment at 40 °C. [1]

(iii) The rate of reaction increases when the frequency of successful collisions between reactant particles increases.

Explain why an increase in temperature produces this effect.

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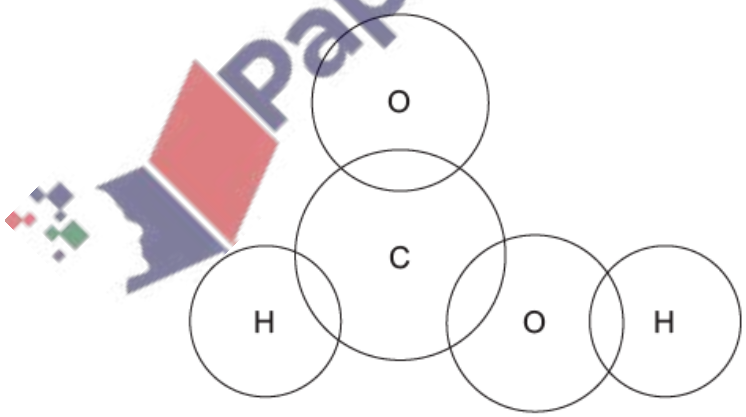
..... [2]

(d) Complete the 'dot-and-cross' diagram, showing outer electrons only, to show the bonding in methanoic acid, HCO_2H.



[2]

[Total: 9]