Access Tuition

A-Level Chemistry

Energetics
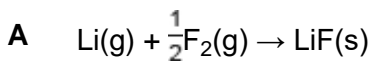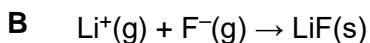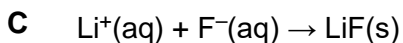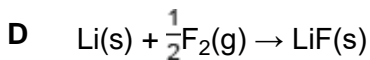## (Multiple Choice)

Question Paper

Time available: 33 minutes
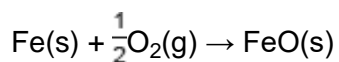**Marks available: 30 marks**

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1. Which reaction has an enthalpy change equal to the standard enthalpy of formation of lithium fluoride?
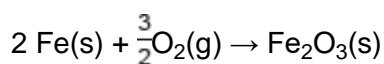
A $\quad Li(g) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$ ⬭

B $\quad Li^+(g) + F^-(g) \rightarrow LiF(s)$ ⬭

C $\quad Li^+(aq) + F^-(aq) \rightarrow LiF(s)$ ⬭

D $\quad Li(s) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$ ⬭

(Total 1 mark)

2. Two reactions of iron with oxygen are shown.

$Fe(s) + \frac{1}{2}O_2(g) \rightarrow FeO(s)$ $\qquad \Delta H = -272$ kJ mol^{-1}

$2\,Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$ $\qquad \Delta H = -822$ kJ mol^{-1}

What is the enthalpy change, in kJ mol^{-1}, for this reaction?

$$2\,FeO(s) + \frac{1}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

A $\quad +550$ ⬭

B $\quad -278$ ⬭

C $\quad -1094$ ⬭

D $\quad -1372$ ⬭
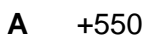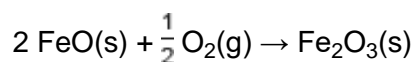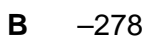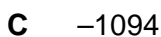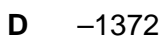
(Total 1 mark)

3. Some enthalpy change data are shown.

$$C(s) + 2\,H_2(g) \rightarrow CH_4(g) \qquad \Delta H = -75 \text{ kJ mol}^{-1}$$

$$H_2(g) \rightarrow 2\,H(g) \qquad \Delta H = +436 \text{ kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol^{-1}, for the following reaction?

$$CH_4(g) \rightarrow C(s) + 4\,H(g)$$
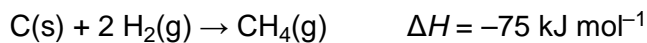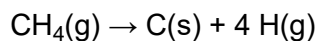
A   −947   ⬭

B   −361   ⬭

C   +361   ⬭

D   +947   ⬭

(Total 1 mark)

4. The temperature changed from 21.8 °C to 19.2 °C during a calorimetry experiment.

The uncertainty of each reading of the thermometer is ±0.1 °C

What is the percentage uncertainty in the temperature change?

A   0.5%   ⬭

B   1.0%   ⬭

C   3.8%   ⬭

D   7.7%   ⬭

(Total 1 mark)

5. Which equation represents the reaction that has a standard enthalpy change equal to the standard enthalpy of formation for barium chloride?

A $Ba(g) + Cl_2(g) \rightarrow BaCl_2(s)$

B $Ba^{2+}(g) + 2\,Cl^-(g) \rightarrow BaCl_2(s)$

C $Ba(s) + Cl_2(g) \rightarrow BaCl_2(s)$

D $Ba^{2+}(s) + 2\,Cl^-(g) \rightarrow BaCl_2(s)$
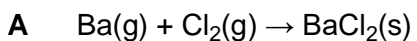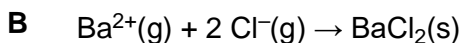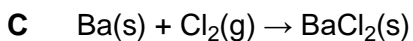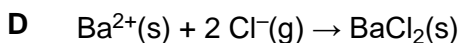
(Total 1 mark)

6. Some fuel in a spirit burner is burned, and the heat produced is used to heat a container of water.
In this experiment:
The mass of water heated = m g
The temperature rise = y °C
The specific heat capacity of water = c J K^{-1} g^{-1}

What is the amount of heat energy absorbed by the water?

A mcy

B $mc(y + 273)$

C $y\,/\,mc$

D $(y + 273)\,/\,mc$

(Total 1 mark)

7. Nitrogen dioxide is produced from ammonia and air as shown in these equations
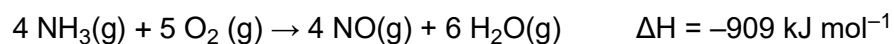
$$4\,NH_3(g) + 5\,O_2(g) \rightarrow 4\,NO(g) + 6\,H_2O(g) \qquad \Delta H = -909 \text{ kJ mol}^{-1}$$

$$2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g) \qquad \Delta H = -115 \text{ kJ mol}^{-1}$$

What is the enthalpy change (in kJ mol^{-1}) for the following reaction?

$4\,NH_3(g) + 7\,O_2(g) \rightarrow 4\,NO_2(g) + 6\,H_2O(g)$
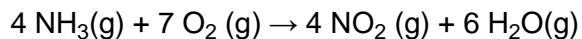
A   −679

B   −794

C   −1024

D   −1139

(Total 1 mark)

8. What is the enthalpy of formation of buta-1,3-diene, $C_4H_6(g)$?

Substance	Enthalpy of combustion / kJ mol^{-1}
$C_4H_6(g)$	−2546
$C(s)$	−394
$H_2(g)$	−286

A   +112 kJ mol^{-1}

B   −112 kJ mol^{-1}

C   +746 kJ mol^{-1}

D   −746 kJ mol^{-1}

(Total 1 mark)

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9. The heat released when 1.00 g of ethanol (M_r = 46.0) undergoes complete combustion is 29.8 kJ

What is the heat released by each molecule, in joules, when ethanol undergoes complete combustion?

(the Avogadro constant $L = 6.022 \times 10^{23}$ mol^{-1})

A 2.28×10^{-18} J   ◯

B 4.95×10^{-20} J   ◯

C 2.28×10^{-21} J   ◯

D 4.95×10^{-23} J   ◯

(Total 1 mark)

10. Calculate the enthalpy change, in kJ, for this dissociation of mole of propan-1-ol.

$$C_3H_7OH(g) \longrightarrow 3C(g) + 8H(g) + O(g)$$
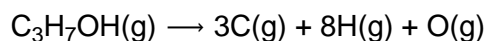
	C—H	C—C	C—O	O—H
Mean bond dissociation enthalpy / kJ mol^{-1}	412	348	360	463

A   −4751   ◯

B   −4403   ◯

C   +4403   ◯

D   +4751   ◯

(Total 1 mark)

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11. What is the temperature rise, in K, when 504 J of heat energy are absorbed by 0.110 kg of solid iron?

Specific heat capacity of iron = 0.448 J K^{-1} g^{-1}

    A 9.78×10^{-2}

    B 1.02×10^{1}

    C 2.83×10^{2}

    D 1.02×10^{4}

(Total 1 mark)

12. Hydrogen is produced by the reaction of methane with steam. The reaction mixture reaches a state of dynamic equilibrium.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$
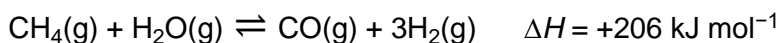
Some enthalpy data is given in the table.

Bond	C–H	O–H	H–H	C≡H
Bond enthalpy / kJ mol^{-1}	413	463	436	To be calculated

Use the information in the table and the stated enthalpy change to calculate the missing bond enthalpy.

    A   234

    B   1064

    C   1476

    D   1936

(Total 1 mark)

13. The table below shows data for the four hydrocarbons ethyne, propyne, propene and propane.
ΔHc is the standard enthalpy of combustion of these hydrocarbons.

Compound	Name	M_r	$-\Delta Hc^{\ominus}$ / kJ mol^{-1}
HC≡CH	ethyne	26	1300
HC≡CCH$_3$	propyne	40	1940
H$_2$C=CHCH$_3$	propene	42	2060
CH$_3$CH$_2$CH$_3$	propane	44	2220

The complete combustion of 2.0 g of one of the above hydrocarbons releases exactly 100 kJ of heat energy.

This hydrocarbon is

A   ethyne

B   propyne

C   propene

D   propane

(Total 1 mark)

14. This question is about the reaction given below.

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

Enthalpy data for the reacting species are given in the table below.

Substance	CO(g)	H$_2$O(g)	CO$_2$(g)	H$_2$(g)
$\Delta H_r^{\ominus}$ / kJ mol^{-1}	−110	−242	−394	0

The standard enthalpy change for this reaction of carbon monoxide and steam is

A   +42 kJ mol^{-1}

B   −42 kJ mol^{-1}

C   +262 kJ mol^{-1}

D   −262 kJ mol^{-1}

(Total 1 mark)

15. Use the information below to answer this question.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad\qquad \Delta H^{\ominus} = -394 \text{ kJ mol}^{-1}$$

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

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g) \qquad\qquad \Delta H^{\ominus} = -126 \text{ kJ mol}^{-1}$$
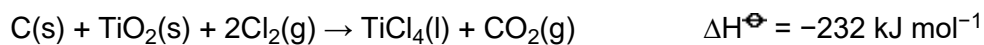
The standard enthalpy of combustion of butane, in kJ mol^{-1}, is

A   −2880

B   −2590

C   −806

D   −554

(Total 1 mark)

16. Using the data below, which is the correct value for the standard enthalpy of formation for $TiCl_4(l)$?

$$C(s) + TiO_2(s) + 2Cl_2(g) \rightarrow TiCl_4(l) + CO_2(g) \qquad \Delta H^{\ominus} = -232 \text{ kJ mol}^{-1}$$

$$Ti(s) + O_2(g) \rightarrow TiO_2(s) \qquad\qquad \Delta H_f^{\ominus} = -912 \text{ kJ mol}^{-1}$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad\qquad \Delta H_f^{\ominus} = -394 \text{ kJ mol}^{-1}$$

A   −1538 kJ mol^{-1}

B   −1094 kJ mol^{-1}

C   −750 kJ mol^{-1}

D   +286 kJ mol^{-1}

(Total 1 mark)

17. Using the information below, answer this question.

$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(g)$ $\Delta H^{\ominus}= +96$ kJ mol^{-1}, $\Delta S^{\ominus} = +138$ J K^{-1} mol^{-1}
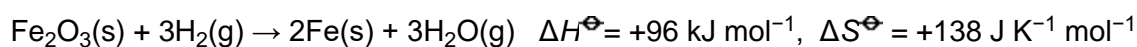
	$Fe_2O_3(s)$	$H_2(g)$	$Fe(s)$
$\Delta H_r^{\ominus}$ / kJ mol^{-1}	−822.0	0	0
$\Delta S^{\ominus}$ / J K^{-1} mol^{-1}	90.0	131.0	27.0

The standard enthalpy of formation of steam is

A   +286 kJ mol^{-1}

B   +242 kJ mol^{-1}

C   −242 KJ mol^{-1}

D   −286 kJ mol^{-1}

(Total 1 mark)

18. The data below refer to the industrial production of nitric acid from ammonia.

Reaction 1 $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H^{\ominus} = -909$ kJ mol^{-1}

Reaction 2 $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ $\Delta H^{\ominus} = -115$ kJ mol^{-1}

Reaction 3 $3NO_2(g) + H_2O(l) \rightleftharpoons 2HNO_3(aq) + NO(g)$ $\Delta H^{\ominus} = -117$ kJ mol^{-1}
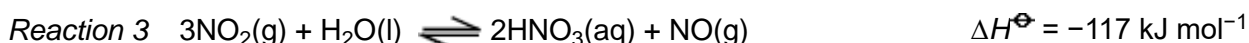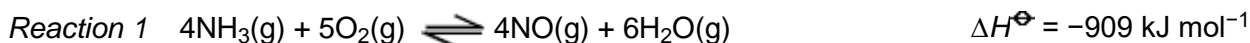
The direct oxidation of ammonia to nitrogen dioxide can be represented by the equation

$$4NH_3(g) + 7O_2(g) \rightarrow 4NO_2(g) + 6H_2O(g)$$
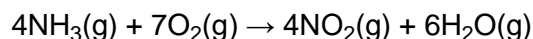
for which the standard enthalpy change, in kJ mol^{-1}, is
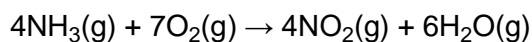
A   −1139

B   −1024

C   −794

D   −679

(Total 1 mark)

19. Nitric acid is produced industrially from ammonia, air and water using the following sequence of reactions:

    (1) $4NH_3 (g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$ $\Delta H = -909$ kJ mol^{-1}

    (2) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $\Delta H = -115$ kJ mol^{-1}

    (3) $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$ $\Delta H = -117$ kJ mol^{-1}

Which is the enthalpy change (in kJ mol^{-1}) for the following reaction?

    $4NH_3(g) + 7O_2(g) \rightarrow 4NO_2(g) + 6H_2O(g)$

A   −679

B   −794

C   −1024

D   −1139

(Total 1 mark)

20. An experiment is done to determine the enthalpy of combustion of a fuel using a calorimeter containing water.

b = mass of fuel burned / g
w = mass of water heated / g
ΔT = temperature rise of water / K
M_r = relative molecular mass of fuel
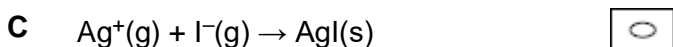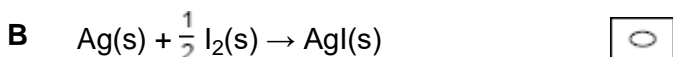c = specific heat capacity of water / J K^{-1} g^{-1}

Which expression gives the enthalpy of combustion (in J mol^{-1}), assuming there is no heat loss?

A $-\dfrac{c\,w\,\Delta T\,M_r}{b}$

B $-\dfrac{c\,b\,\Delta T\,M_r}{w}$

C $-\dfrac{c\,b\,w\,M_r}{\Delta T}$

D $-\dfrac{c\,b\,w\,\Delta T}{M_r}$

(Total 1 mark)

21. Which reaction has an enthalpy change equal to the standard enthalpy of formation of silver iodide?
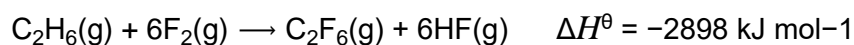
A $Ag(g) + \frac{1}{2}I_2(g) \rightarrow AgI(s)$ ⬭

B $Ag(s) + \frac{1}{2}I_2(s) \rightarrow AgI(s)$ ⬭

C $Ag^+(g) + I^-(g) \rightarrow AgI(s)$ ⬭

D $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$ ⬭

(Total 1 mark)

22. Which one of the following has the most covalent character?

A MgF_2

B $MgBr_2$

C AlF_3

D $AlBr_3$

(Total 1 mark)

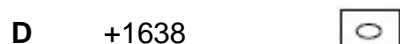**23.** The table shows the standard enthalpy of formation, $\Delta_f H^\theta$, for some of the substances in the reaction

$$C_2H_6(g) + 6F_2(g) \longrightarrow C_2F_6(g) + 6HF(g) \quad \Delta H^\theta = -2898 \text{ kJ mol}-1$$

	$C_2H_6(g)$	$C_2F_6(g)$
$\Delta_f H^\theta$ /kJ mol^{-1}	−84	−1344

What is the standard enthalpy of formation, in kJ mol^{-1}, for HF(g)?

A   −1638 ⬭

B   −273 ⬭

C   +273 ⬭

D   +1638 ⬭
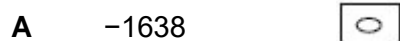
(Total 1 mark)

24. Use the information below to answer this question.

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad\quad\quad\quad \Delta H^\ominus = -393.5 \text{ kJ mol}^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\quad\quad \Delta H^\ominus = -285.8 \text{ kJ mol}^{-1}$

$3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$ $\quad\quad \Delta H^\ominus = -104.0 \text{ kJ mol}^{-1}$

$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$ $\quad\quad \Delta H^\ominus = -125.2 \text{ kJ mol}^{-1}$

The value in kJ mol^{-1} of the enthalpy of thermal dissociation when butane forms propane, hydrogen and carbon is

A −26.3

B −17.5

C +17.5

C +21.2

(Total 1 mark)

25. Use the information below to answer this question.

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad\quad\quad\quad \Delta H^\ominus = -393.5 \text{ kJ mol}^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\quad\quad \Delta H^\ominus = -285.8 \text{ kJ mol}^{-1}$

$3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$ $\quad\quad \Delta H^\ominus = -104.0 \text{ kJ mol}^{-1}$

$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$ $\quad\quad \Delta H^\ominus = -125.2 \text{ kJ mol}^{-1}$

The value in kJ mol^{-1} for the enthalpy of combustion of propane is

A −211.7

B −419.7

C −2220

C −2878

(Total 1 mark)

26. When 0.10 g of propane was burned the quantity of heat evolved was 5.0 kJ. The enthalpy of combustion of propane in kJ mol^{-1} is

A   −800

B   −1500

C   −2200

D   −2900

(Total 1 mark)

27. When ethanamide (CH_3CONH_2) burns in oxygen the carbon is converted into carbon dioxide, the hydrogen is converted into water and the nitrogen forms nitrogen gas.

Substance	ethanamide	carbon dioxide	water
Enthalpy of formation ($\Delta H_f^{\ominus}$) / kJ mol^{-1}	−320	−394	−286

Using the data above, which one of the following is a correct value for the enthalpy of combustion of ethanamide?

A   −1823 kJ mol^{-1}

B   −1183 kJ mol^{-1}

C   −1000 kJ mol^{-1}
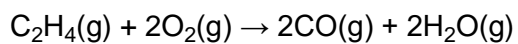
D   −360 kJ mo1^{-1}

(Total 1 mark)

28. In which one of the following reactions is the standard enthalpy change equal to the standard enthalpy of formation of lithium fluoride?

A   Li(g) + F(g) → LiF(s)

B   Li$^+$(g) + F$^-$(g) → LiF(s)

C   Li$^+$(aq) + F$^-$(g) → LiF(s)

D   Li(s) + $\frac{1}{2}$F$_2$(g) → LiF(s)

(Total 1 mark)

29. Consider the reactions

$$C_2H_4(g) + 2O_2(g) \rightarrow 2CO(g) + 2H_2O(g) \qquad \Delta H^\ominus = -758 \text{ kJ mol}^{-1}$$

$$2C(s) + 2H_2(g) \rightarrow C_2H_4(g) \qquad \Delta H^\ominus = +52 \text{ kJ mol}^{-1}$$
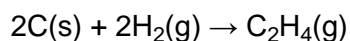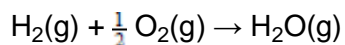
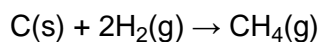$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g) \qquad \Delta H^\ominus = -242 \text{ kJ mol}^{-1}$$

The enthalpy of formation of carbon monoxide is

A -111 kJ mol^{-1}

B -163 kJ mol^{-1}

C -222 kJ mol^{-1}

D -464 kJ mol^{-1}

(Total 1 mark)

30. Given the following data

$$C(s) + 2H_2(g) \rightarrow CH_4(g) \qquad \Delta H = -75 \text{ kJ mol}^{-1}$$
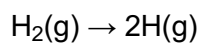
$$H_2(g) \rightarrow 2H(g) \qquad \Delta H = +436 \text{ kJ mol}^{-1}$$

which one of the following is the enthalpy change, in kJ mol^{-1}, of the reaction below?

$$CH_4(g) \rightarrow C(s) + 4H(g)$$
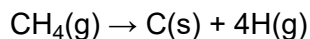
A -947

B $+511$

C $+797$

D $+947$

(Total 1 mark)