

Physical Chemistry

Question Paper 2

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Physical Chemistry
Booklet	Question Paper 2

Time Allowed: 35 minutes

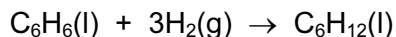
Score: /29

Percentage: /100

Grade Boundaries:

Energy Changes

1. Cyclohexane, C_6H_{12} , is prepared industrially by the hydrogenation of benzene as shown in the equation.



Using the data in the table, what is the standard enthalpy change, $\Delta_r H^\ominus$, of this reaction?

enthalpy change	value
$\Delta_c H^\ominus (C_6H_6(l))$	$-3268 \text{ kJ mol}^{-1}$
$\Delta_c H^\ominus (H_2(g))$	-286 kJ mol^{-1}
$\Delta_c H^\ominus (C_6H_{12}(l))$	$-3754 \text{ kJ mol}^{-1}$

- A -372 kJ mol^{-1}
 B $+372 \text{ kJ mol}^{-1}$
 C $+200 \text{ kJ mol}^{-1}$
 D -200 kJ mol^{-1}
2. At temperatures below 13°C white tin, a shiny, ductile metallic solid, changes slowly into grey tin which is brittle.

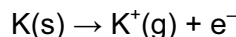
Data for each form of tin are given.

	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{JK}^{-1} \text{ mol}^{-1}$
white	0	51.4
grey	-2.09	44.1

What is the expression for ΔG^\ominus , in J mol^{-1} , for the formation of grey tin from white tin at 12°C ?

- A $\Delta G^\ominus = -2.09 - 285 \times (-7.3)$
 B $\Delta G^\ominus = -2.09 - 12 \times (+7.3)$
 C $\Delta G^\ominus = -2090 - 12 \times (+7.3)$
 D $\Delta G^\ominus = -2090 - 285 \times (-7.3)$

3. An energy change accompanies the reaction shown.

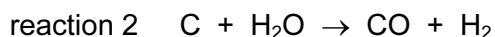
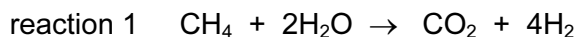


What is equal to the value of this energy change?

- A the enthalpy change of vaporisation of potassium
 - B the first ionisation energy of potassium
 - C the sum of the enthalpy change of atomisation and the electron affinity of potassium
 - D the sum of the enthalpy change of atomisation and the first ionisation energy of potassium
4. Which equation does **not** represent the standard enthalpy change stated?

	enthalpy change of	equation
A	atomisation of Cl	$\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$
B	combustion of H ₂ S	$\text{S}(\text{g}) + 1.5\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{SO}_2(\text{g})$
C	formation of H ₂ SO ₄	$\text{H}_2(\text{g}) + 2\text{O}_2(\text{g}) + \frac{1}{8}\text{S}_8(\text{s}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$
D	solution of K ₂ SO ₄	$\text{K}_2\text{SO}_4(\text{s}) + \text{aq} \rightarrow 2\text{K}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

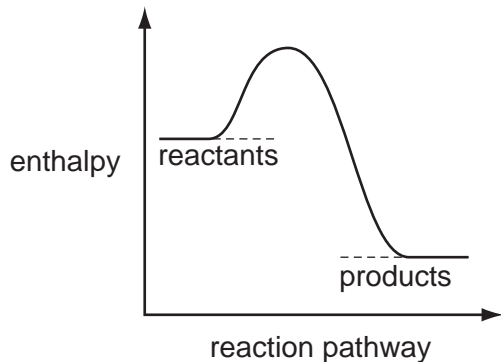
5. Which quantity is **not** required in the calculation of the lattice energy of calcium hydride, CaH₂, using the Born-Haber cycle?
- A first electron affinity of hydrogen
 - B second electron affinity of hydrogen
 - C first ionisation energy of calcium
 - D second ionisation energy of calcium
6. Hydrogen, used as a reactant in the Haber process, can be produced industrially from either of the two reactions shown.



Assume hydrogen is the only utilised product. Which statement about the relative efficiencies of reagent use of these two reactions is correct?

- A Reaction 1 is more efficient because it has a higher atom economy.
- B Reaction 1 is more efficient because it has a lower atom economy.
- C Reaction 2 is more efficient because it has a higher atom economy.
- D Reaction 2 is more efficient because it has a lower atom economy.

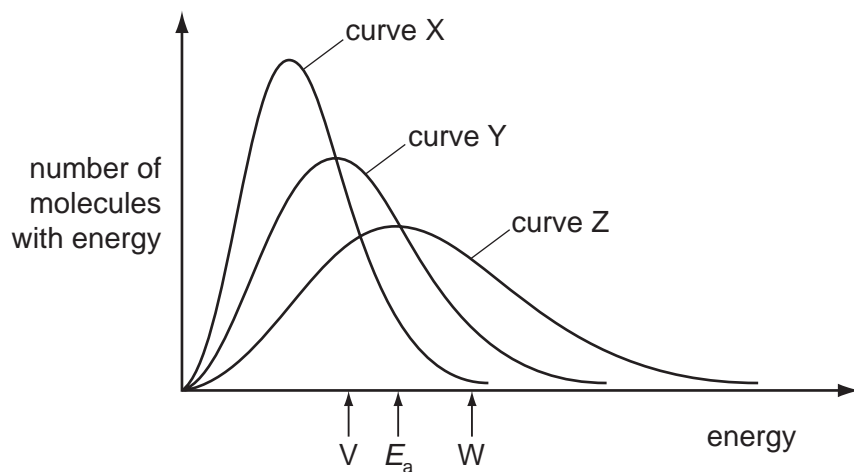
7. Which enthalpy change could **never** be correctly represented by the following enthalpy diagram?



- A standard enthalpy change of combustion
 B standard enthalpy change of formation
 C standard enthalpy change of hydration
 D standard enthalpy change of vaporisation
8. Which value is essential to calculate the lattice energy of the compound NaH?

- A electron affinity of hydrogen
 B electron affinity of sodium
 C first ionisation of hydrogen
 D second ionisation energy of sodium

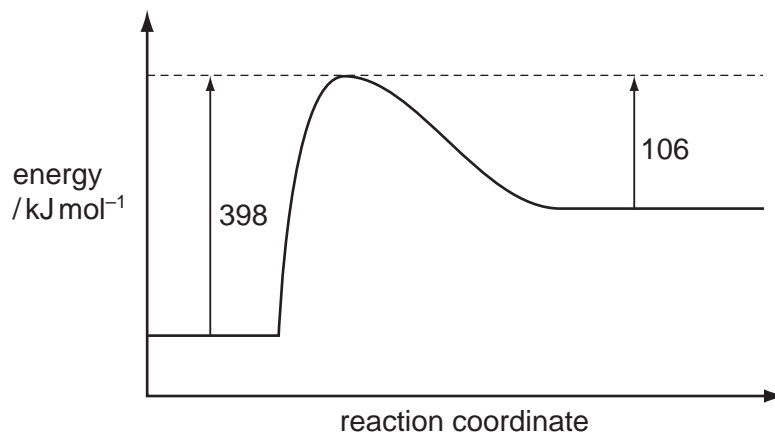
9. The curve Y and the value E_a represent the distribution of energies of the molecules and the activation energy for an uncatalysed gaseous reaction.



What is a possible outcome if the reaction is catalysed?

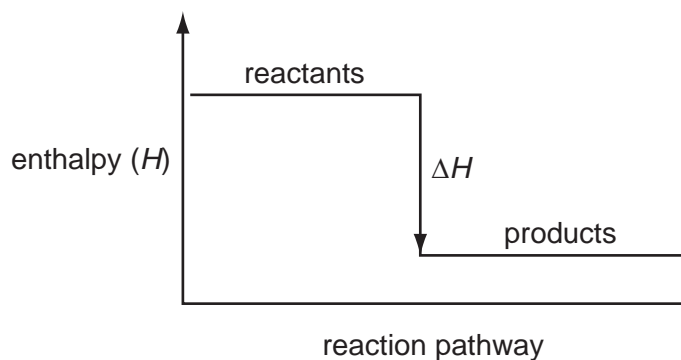
- A The distribution of energies will be given by curve X and the activation energy by value V.
 B The distribution of energies will be given by curve Y and the activation energy by value V.
 C The distribution of energies will be given by curve Y and the activation energy by value W.
 D The distribution of energies will be given by curve Z and the activation energy by value W.

10. The diagram shows the energy profile for a simple reaction.



Which statement about the reaction is correct?

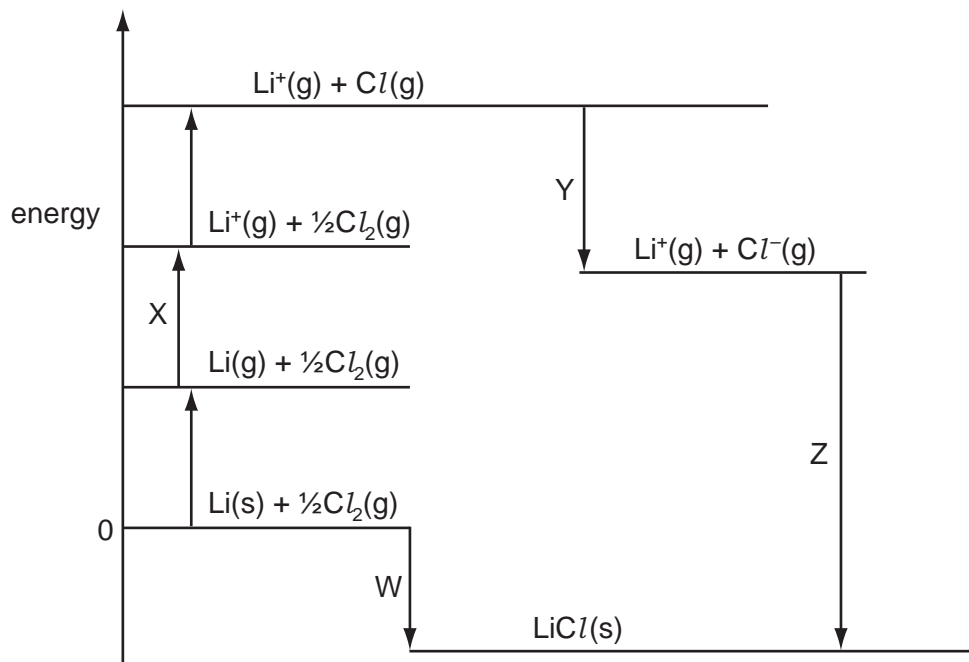
- A The reaction is endothermic and the enthalpy change of reaction ($\Delta_r H$) is $+292 \text{ kJ mol}^{-1}$.
 - B The reaction is endothermic and the enthalpy change of reaction ($\Delta_r H$) is $+504 \text{ kJ mol}^{-1}$.
 - C The reaction is exothermic and the enthalpy change of reaction ($\Delta_r H$) is -292 kJ mol^{-1} .
 - D The reaction is exothermic and the enthalpy change of reaction ($\Delta_r H$) is -504 kJ mol^{-1} .
11. Which enthalpy change could **not** be correctly represented by the enthalpy diagram shown?



- A standard enthalpy change of atomisation
- B standard enthalpy change of combustion
- C standard enthalpy change of hydration
- D standard enthalpy change of neutralisation

12. Many compounds containing lithium, such as lithium chloride, have pharmacological uses.

The diagram shows the Born-Haber cycle showing the formation of lithium chloride.

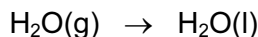


What are the correct names of the four steps W, X, Y and Z?

	W	X	Y	Z
A	enthalpy of formation	ionisation energy	enthalpy of atomisation	lattice energy
B	enthalpy of formation	ionisation energy	electron affinity	lattice energy
C	lattice energy	enthalpy of atomisation	electron affinity	enthalpy of formation
D	lattice energy	enthalpy of atomisation	ionisation energy	enthalpy of formation

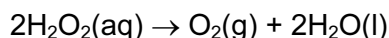
Entropy

- 13.. Clouds and rain form when air saturated with water vapour cools.



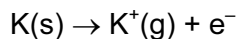
What are the correct signs of ΔH and ΔS for this reaction?

- A** both negative
 - B** both positive
 - C** ΔH negative, ΔS positive
 - D** ΔH positive, ΔS negative
14. At room temperature, hydrogen peroxide decomposes slowly according to the equation.



Which statement correctly explains the result of carrying out this decomposition in the presence of a catalyst such as MnO_2 ?

- A** The reaction rate increases because the collision frequency increases due to a decrease in the activation energy.
 - B** The reaction rate increases because the collision frequency increases due to an increase in the average energy of the molecules.
 - C** The reaction rate increases because the proportion of successful collisions increases due to a decrease in the activation energy.
 - D** The reaction rate increases because the proportion of successful collisions increases due to an increase in the average energy of the molecules.
15. An energy change accompanies the reaction shown.



What is equal to the value of this energy change?

- A** the enthalpy change of vaporisation of potassium
- B** the first ionisation energy of potassium
- C** the sum of the enthalpy change of atomisation and the electron affinity of potassium
- D** the sum of the enthalpy change of atomisation and the first ionisation energy of potassium

Acids and Bases

16. Which species is dominant when equal volumes of aqueous solutions of $0.1 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$, $0.1 \text{ mol dm}^{-3} \text{ NaOH}$ and $0.1 \text{ mol dm}^{-3} \text{ H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$ are mixed?

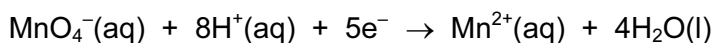
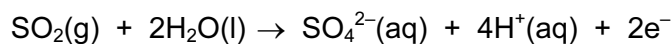
- A $\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$
- B $\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2^-$
- C $\text{H}_3\text{N}^+\text{CH}(\text{CH}_3)\text{CO}_2^-$
- D $\text{H}_3\text{N}^+\text{CH}(\text{CH}_3)\text{CO}_2\text{H}$

17. 10 cm^3 of a 0.1 mol dm^{-3} solution of hydrochloric acid was diluted with 90 cm^3 of water.

What is the pH of the resulting mixture?

- A 1
- B 2
- C 3
- D 4

18. Sulfur dioxide gas is converted into sulfate ions when it is bubbled into a solution containing aqueous manganate(VII) ions.

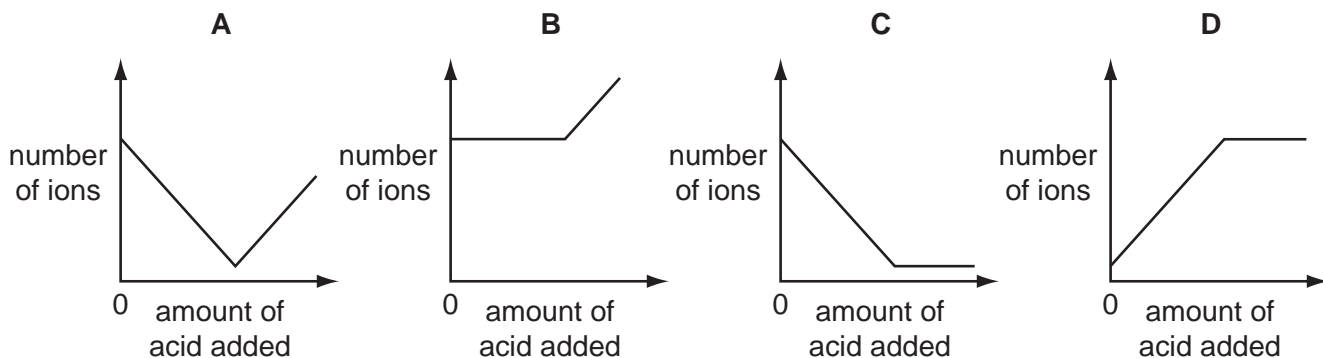


How will the pH of the reaction mixture change as sulfur dioxide is bubbled at constant rate into a well-stirred solution of manganate(VII) ions until its colour just fades?

- A a decrease
- B a decrease then an increase
- C an increase
- D an increase then a decrease

19. Dilute sulfuric acid was added to aqueous barium hydroxide until the acid was present in excess.

How will the total number of ions present in solution in the reacting mixture vary?



20. A protonated oxoanion of vanadium has been characterised at pH3 with the formula $\text{HV}_{10}\text{O}_{28}^{5-}$.

Which oxoanion contains vanadium in a **different** oxidation state from that shown in $\text{HV}_{10}\text{O}_{28}^{5-}$?

- A** VO_2^+ **B** VO^{2+} **C** $\text{V}_4\text{O}_{12}^{4-}$ **D** VO_4^{3-}

21. Four compounds of period 3 elements are listed.



Water is added to each of the four compounds.

Pairs of the resulting solutions are mixed together.

From which pair of solutions is it possible to get a solution with a pH of 7?

- A** NaCl and Na_2O
B NaCl and SO_2
C Na_2O and SiCl_4
D SiCl_4 and SO_2

22. Four compounds of period 3 elements are listed.



Water is added to each of the four compounds.

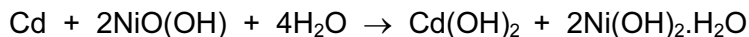
Pairs of the resulting solutions are mixed together.

From which pair of solutions is it possible to get a solution with a pH of 7?

- A NaCl and Na_2O
- B NaCl and SO_2
- C Na_2O and SiCl_4
- D SiCl_4 and SO_2

Electrolysis

23. The nickel-cadmium rechargeable battery is based upon the following overall reaction.



What is the oxidation number of nickel at the beginning and at the end of the reaction?

	beginning	end
A	+1.5	+2
B	+2	+3
C	+3	+2
D	+3	+4

24. What mass of lead would be produced at the cathode on electrolysis of molten PbBr_2 by a current of 1 amp flowing for 30 minutes?

- A** 0.03g
B 0.76g
C 1.93g
D 3.86g

25. The thermal decomposition of ammonium nitrate gives only two products, steam and an oxide of nitrogen, **X**.

What is the oxidation number of nitrogen in **X**?

- A** +1 **B** +2 **C** +3 **D** +4

26. In an experiment, 50.0 cm^3 of a $0.100 \text{ mol dm}^{-3}$ solution of a metal nitrate $M(\text{NO}_3)_3$ reacted exactly with 25.0 cm^3 of a $0.100 \text{ mol dm}^{-3}$ solution of sodium sulfite.

During this reaction the sulfite ions were oxidised.



The original solution of the metal salt contained M^{3+} ions.

What is the oxidation number of the metal in the final reaction mixture?

- A** +1 **B** +2 **C** +4 **D** +5

27. During the electrolysis of molten aluminium oxide, Al^{3+} ions are converted to aluminium metal at the cathode.

How many electrons are required to produce 81.0g of aluminium?

[L = the Avogadro constant]

A 9L

B 3L

C L

D $\frac{L}{3}$

Rate of Reaction

28. How does a catalyst function?

- A by providing the same reaction pathway and increasing the average energy of the molecules
- B by providing an alternative reaction pathway and increasing the average energy of the molecules
- C by providing the same reaction pathway with a lower activation energy
- D by providing an alternative reaction pathway with a lower activation energy

29. A given mass of an ideal gas occupies a volume V and exerts a pressure p at 27°C .

At which temperature will the same mass of the ideal gas occupy the same volume V and exert a pressure $2p$?

- A 50°C
- B 54 K
- C 600°C
- D 600 K