PART Y Chemistry

21 The table gives standard enthalpy change data measured at 25 °C.

reaction	*standard enthalpy change* / kJ mol^{-1}
$H(g) + Br(g) \rightarrow HBr(g)$	−366
$H(g) + Br(g) \rightarrow H^+(g) + Br^-(g)$	+968
$HBr(g) \rightarrow H^+(aq) + Br^-(aq)$	−92

What is the standard enthalpy change for the following reaction at 25 °C?

$$H^+(g) + Br^-(g) \rightarrow H^+(aq) + Br^-(aq)$$

A −510 kJ mol^{-1}

B +510 kJ mol^{-1}

C −694 kJ mol^{-1}

D +694 kJ mol^{-1}

E −1242 kJ mol^{-1}

F +1242 kJ mol^{-1}

G −1426 kJ mol^{-1}

H +1426 kJ mol^{-1}

22 Alpha-linolenic acid is a polyunsaturated straight-chain carboxylic acid.

0.001 mol of the acid reacts exactly with 15 cm^3 of 0.2 mol dm^{-3} aqueous bromine.

Alpha-linolenic acid contains 18 carbon atoms per molecule.

Which of the following is a formula for the acid?

A $C_{17}H_{35}COOH$

B $C_{17}H_{34}COOH$

C $C_{17}H_{33}COOH$

D $C_{17}H_{32}COOH$

E $C_{17}H_{31}COOH$

F $C_{17}H_{30}COOH$

G $C_{17}H_{29}COOH$

H $C_{17}H_{28}COOH$

23 25.0 g of compound X contains 9.75 g of potassium, 0.25 g of hydrogen and 12.0 g of oxygen.

When heated strongly, compound X produces a gas that turns limewater cloudy.

The chemical formula of X is the same as its empirical formula.

Compound X is the only product formed between substance Y and two further substances. One of these is the fourth most abundant gas in clean dry air, and the other changes the colour of anhydrous copper(II) sulfate from white to blue.

Which of the following could be the identity of substance Y?

(A_r values: H = 1; C = 12; O = 16; K = 39)

A K

B K_2CO_3

C K_2O_3

D $KHCO_3$

E CH_3COOK

24 Strontium (Sr) is a Group 2 metal.

Strontium hydride is an ionic compound made up of strontium and hydrogen only.

When a small mass of strontium hydride is added to 180 g of water in an insulated container and stirred, the temperature of the water rises by 25 °C and hydrogen gas is given off.

Assume that:

- the standard enthalpy change of the reaction is $-360\,\text{kJ mol}^{-1}$ of strontium hydride.
- the specific heat capacity of water (and the solution formed) is $4\,\text{J g}^{-1}\,\text{°C}^{-1}$. Ignore any change in mass of the water due to the reaction.
- all heat is transferred to the water only.
- all measurements are made at atmospheric pressure, with all reactants and products in their standard states.
- one mole of a gas occupies $24\,\text{dm}^3$ at room temperature and pressure.

What is the maximum volume of hydrogen (measured at room temperature) that could be released?

A $1.20\,\text{dm}^3$

B $1.80\,\text{dm}^3$

C $2.40\,\text{dm}^3$

D $240\,\text{dm}^3$

E $480\,\text{dm}^3$

F $2400\,\text{dm}^3$

25 Element X forms the most soluble hydroxide of the hydroxides of the Group 2 elements in the range Mg to Ba.

$50\,cm^3$ of a $0.2\,mol\,dm^{-3}$ aqueous solution of an acid Y is exactly neutralised by $400\,cm^3$ of a $0.05\,mol\,dm^{-3}$ aqueous solution of potassium hydroxide.

$100\,cm^3$ of a $0.1\,mol\,dm^{-3}$ aqueous solution of Y is titrated with an aqueous solution of the hydroxide of X until the acid is exactly neutralised.

Which statement about one product of the titration could be correct?

A 0.005 mol of barium chloride is formed.

B 0.05 mol of barium chloride is formed.

C 0.005 mol of magnesium chloride is formed.

D 0.05 mol of magnesium chloride is formed.

E 0.01 mol of barium sulfate is formed.

F 0.1 mol of barium sulfate is formed.

G 0.01 mol of magnesium sulfate is formed.

H 0.1 mol of magnesium sulfate is formed.

26 In the presence of a suitable catalyst, 30.0 cm^3 of a 0.10 mol dm^{-3} aqueous solution of $Na_2C_2O_4$ reacts exactly with 40.0 cm^3 of a 0.15 mol dm^{-3} aqueous solution of $Ce(SO_4)_2$.

The only products of the reaction are another cerium salt, a different water-soluble salt and carbon dioxide.

What is the cerium ion formed by this reaction?

A Ce^{+}

B Ce^{2+}

C Ce^{3+}

D Ce^{4+}

E Ce^{5+}

27 Consider all of the structural isomers of C_4H_9Br and the ways that they could react with hydroxide ions from aqueous sodium hydroxide.

How many different organic products (including all structural and *E*/*Z* isomers only) containing four carbons could be made?

A 4

B 5

C 6

D 7

E 8

F 9

28 In which of the following conversions does the stated bond angle decrease?

1 hydrogen–nitrogen–hydrogen bond angle in the conversion from NH_3 to NH_4^+

2 fluorine–iodine–fluorine bond angle in the conversion from IF_4^- to IF_6^+

3 chlorine–aluminium–chlorine bond angle in the conversion from $AlCl_3$ to $AlCl_4^-$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

29 Ethanol combines with ethanoic acid to form ethyl ethanoate according to the following reaction.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l) \qquad \Delta H = -6\,kJ\,mol^{-1} \text{ at } 25\,°C$$

A mixture of 9.2 g ethanol, 12 g ethanoic acid and 8.8 g ethyl ethanoate is allowed to react and reach equilibrium.

The resulting equilibrium mixture is found to contain 4.8 g ethanoic acid at 25 °C and K_c was calculated.

What will happen to the value of K_c when the temperature is increased from 25 °C to 45 °C?

(M_r values: C_2H_5OH = 46; CH_3COOH = 60; $CH_3COOC_2H_5$ = 88; H_2O = 18)

A It increases from an initial value of 0.242

B It decreases from an initial value of 0.242

C It increases from an initial value of 1.833

D It decreases from an initial value of 1.833

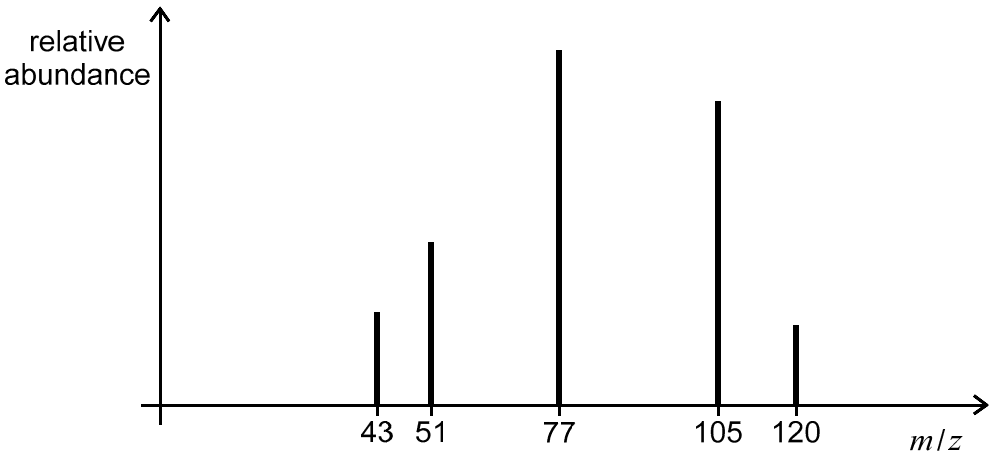
E It increases from an initial value of 2.750

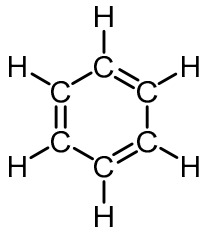
F It decreases from an initial value of 2.750

G It increases from an initial value of 4.125

H It decreases from an initial value of 4.125

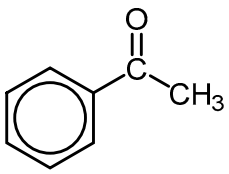
30 Compound Z is known to have percentage composition by mass C: 80.0%, H: 6.7%, O: 13.3%. The mass spectrum of compound Z is given showing the mass-to-charge ratio (m/z) of the molecular ion and its fragments.

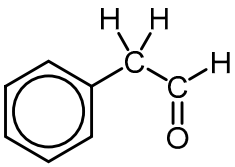



and

are representations of the same molecule

Which of the following could be the structure of Z?

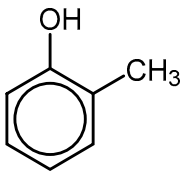
(A_r values: C = 12; H = 1; O = 16)

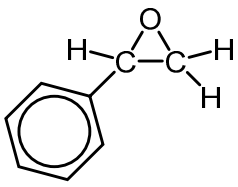
A


B


C $CH_3CH_2CH_2CH(OH)CH(OH)CH_3$

D CH_2=CHCH=CHCH=CH–CH=C=O

E


F


31 The time it takes the ion ${}^{1}_{1}H^{+}$ to travel through the flight tube in a time-of-flight mass spectrometer is t.

How long would it take the ion ${}^{2}_{1}H^{+}$ to travel through the same flight tube?

A $\frac{1}{4}t$

B $\frac{1}{2}t$

C $\frac{1}{\sqrt{2}}t$

D $\sqrt{\frac{2}{3}}t$

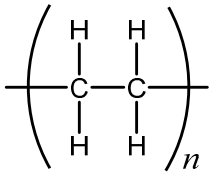
E $\sqrt{\frac{3}{2}}t$

F $\sqrt{2}t$

G $2t$

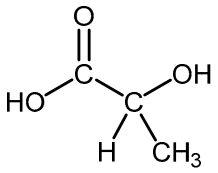
H $4t$

32 A paper coffee cup is lined with a thin layer of plastic to make it waterproof. This plastic makes up 5% of the mass of the cup and has the following molecular structure.



960 dm^3 of a gaseous hydrocarbon monomer (measured at room temperature and pressure) was used to make a certain number of plastic-lined cups.

It is proposed that a more environmentally-friendly, biodegradable plastic, poly(lactic acid), could be used instead in the same proportions by mass (5%). Assume that any polymerisation reaction has a 100% yield.



lactic acid

What mass of lactic acid (M_r = 90) is required to make the same number of biodegradable cups?

(A_r values: H = 1; C = 12; O = 16. Assume that one mole of a gas occupies 24 dm^3 at room temperature and pressure.)

A 896 g

B 1120 g

C 1200 g

D 1400 g

E 1500 g

F 3000 g

G 3600 g

33 In which of the following pairs do **both** molecules possess permanent dipoles in the gaseous state?

1 methylamine (CH_3NH_2) and dichlorine monoxide (Cl_2O)

2 difluoroethyne (C_2F_2) and sulfur hexafluoride

3 phosphorus trichloride and xenon tetrafluoride

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

34 At high temperatures, carbon dioxide reacts partially with solid carbon and forms the following equilibrium.

$$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$$

In an experiment, 1.0 mol of carbon dioxide is placed in a flask of capacity $V\,dm^3$ containing no air and an excess of carbon. It is then heated to a high temperature where an equilibrium between carbon dioxide and carbon monoxide is established. At this temperature, x mol of carbon dioxide converts to carbon monoxide and the value of the equilibrium constant, K_c, is $2.0\,mol\,dm^{-3}$.

As it is a solid, carbon is not included in the equilibrium constant expression.

What is the relationship between the value of x and V?

A $x = \dfrac{-V + \sqrt{V^2 + 32V}}{16}$

B $x = \dfrac{-V + \sqrt{V^2 + 8V}}{4}$

C $x = \dfrac{-2 + \sqrt{4V^2 + 8V}}{4}$

D $x = \dfrac{-2V + \sqrt{4V^2 - 2V}}{2}$

E $x = \dfrac{-2 + \sqrt{4 - 32V}}{4V}$

35 A student carried out an experiment to find the mass of the active ingredient calcium carbonate (M_r = 100) in an indigestion tablet. The student crushed the tablet and placed it in a beaker.

The student added 20.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid, an excess, to the tablet. When the reaction was complete, the reaction mixture was all transferred to a volumetric flask and deionised water added to make the solution up to 250 cm^3.

25.0 cm^3 samples of the solution in the volumetric flask were titrated against 0.100 mol dm^{-3} sodium hydroxide solution. The mean titre was 26.40 cm^3 of sodium hydroxide solution.

Assuming that all other ingredients in the tablet are inert, what is the mass of calcium carbonate in the tablet?

A 0.264 g

B 0.680 g

C 1.36 g

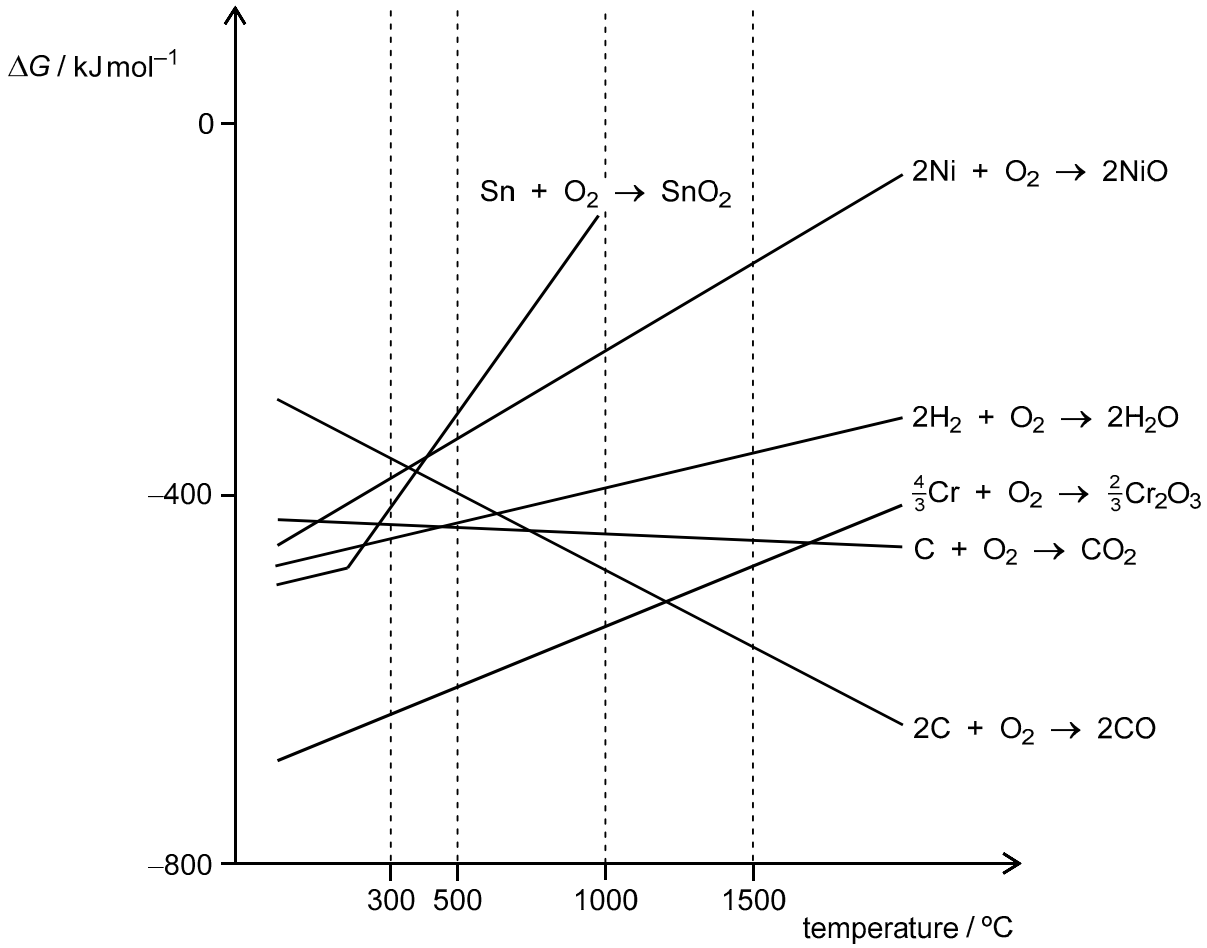
D 1.87 g

E 2.72 g

36 Ellingham diagrams show how the quantity ΔG for a reaction varies over a range of temperatures.

The ΔG values for different reactions can be combined using Hess's law.

For a reaction to be able to occur, the overall value of ΔG must be less than zero.



Using the Ellingham diagram shown, which one of the following statements is correct?

A Nickel can reduce tin(IV) oxide at 300 °C.

B Carbon can reduce chromium(III) oxide at 1500 °C forming carbon dioxide and chromium.

C Chromium(III) oxide and nickel oxide will decompose to their elements at all the temperatures shown.

D Chromium will react with steam at all the temperatures shown.

E Nickel oxide can be reduced by carbon at 300 °C forming carbon monoxide and nickel.

37 $SO_3^{2-}(aq)$ ions can cause the reduction of $VO_3^-(aq)$ ions to $VO^{2+}(aq)$ in acidic solution. During this process, the $SO_3^{2-}(aq)$ ions are oxidised to $SO_4^{2-}(aq)$ ions.

What is the minimum volume of 1.00 mol dm^{-3} sulfuric acid required to provide sufficient hydrogen ions to allow $Na_2SO_3(aq)$ to reduce 40.0 cm^3 of 0.100 mol dm^{-3} $VO_3^-(aq)$ ions completely to $VO^{2+}(aq)$?

A no sulfuric acid is required

B 4.0 cm^3

C 6.0 cm^3

D 6.6 cm^3

E 8.0 cm^3

F 12.0 cm^3

G 13.2 cm^3

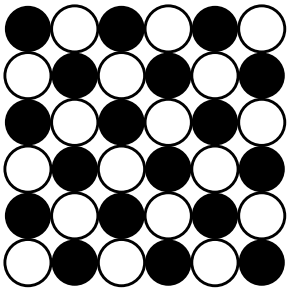
38 Sodium chloride is an ionic compound which forms highly ordered crystals of ions when in the solid state. This is called a lattice.

A lattice can be thought of as a stack of layered planes of ions.

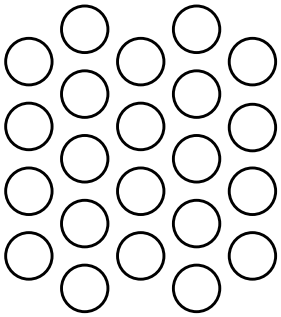
In the following diagrams, the shaded and non-shaded circles represent sodium and chloride ions, respectively.

Which of the following is **not** a representation of a plane present in a sodium chloride lattice?

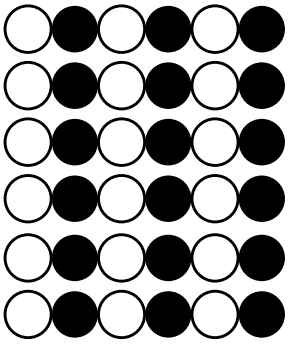
A



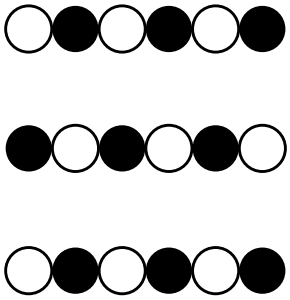
B



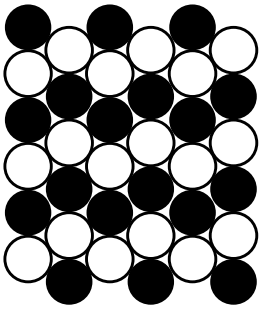
C



D

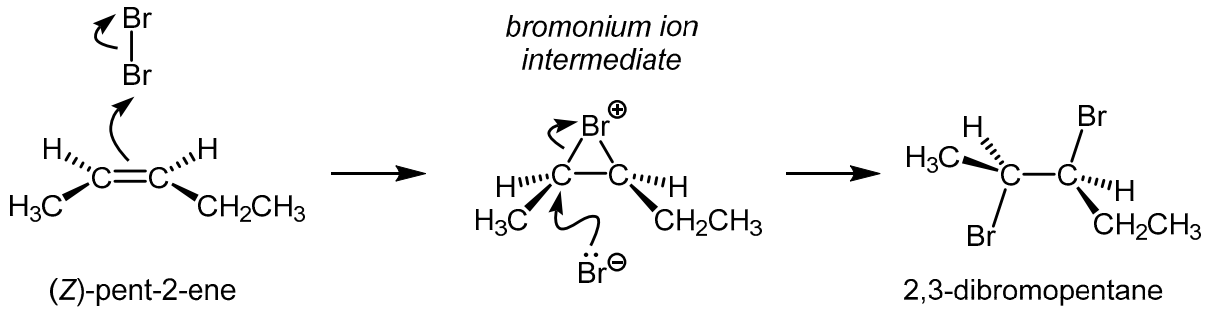


E



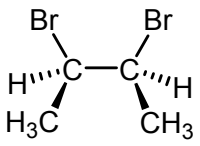
39 When bromine reacts with (*Z*)-pent-2-ene, an intermediate called a bromonium ion forms. This is then attacked by the bromide ion to give the 2,3-dibromopentane addition product.

The mechanism is shown:

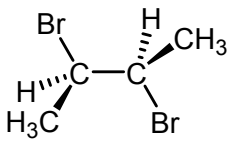


In a different reaction **(*E*)-but-2-ene** is reacted with bromine in an addition reaction. This reaction also occurs via a bromonium ion intermediate.

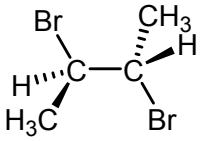
Which of the following structures show the final product of the reaction of **(*E*)-but-2-ene** with bromine?



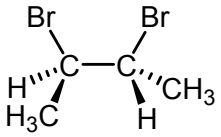
1



2



3



4

A structures 1 and 2 only

B structures 1 and 3 only

C structures 1 and 4 only

D structures 2 and 3 only

E structures 2 and 4 only

F structures 3 and 4 only

G structures 1, 2, 3 and 4

40 Both oxygen and carbon monoxide bind reversibly to haemoglobin.

For the purposes of this question, assume that only one molecule of either oxygen or carbon monoxide can bind to haemoglobin at any one time.

Within the human body, carbon monoxide is 200 times more effective than oxygen in binding to haemoglobin available in human blood. The *binding efficiency* is the equilibrium constant for this process and you may assume that the system is at equilibrium.

The effects of carboxy-haemoglobin in humans can typically be observed when it reaches 5% of the concentration of oxy-haemoglobin in their blood.

Assume that oxygen and carbon monoxide have the same molar solubility in blood.

What is the minimum proportion of carbon monoxide molecules in dry air, expressed as parts per million (ppm), that will result in a 5% ratio of carboxy-haemoglobin molecules to oxy-haemoglobin molecules in blood?

A 10 ppm

B 21 ppm

C 52.5 ppm

D 210 ppm

E 1000 ppm

F 5250 ppm

BLANK PAGE