OCR AS/A-level Year 1 Chemistry A exam practice answers

5 Physical chemistry

**1 (a)** It is the enthalpy change when 1 mole of a covalent bond is broken **✓** in the gaseous state, which results in the formation of neutral particles.**✓**

X−Y(g) → X(g) + Y(g)

**(b) (i)** HCl(g) → H(g) + Cl(g) **✓**

**(ii)** ¼ **✓**{CH4(g) → C(g) + 4H(g)} **✓**

This is difficult (hence 2 marks) because there are four C−H bonds, which are all different (see below) and it is the average C−H bond enthalpy that is used.

CH4(g) → CH3(g) + H(g) Δ*H* = +425 kJ mol−1

CH3(g) → CH2(g) + H(g) Δ*H* = +470 kJ mol−1

CH2(g) → CH (g) + H(g) Δ*H* = +416 kJ mol−1

CH(g) → C(g) + H(g) Δ*H* = +335 kJ mol–1

The total enthalpy change is (+425 + 470 + 416 + 335) = +1646 kJ mol−1, which is the enthalpy change when four C−H bonds are broken in methane and, therefore, the enthalpy change when one C−H bond is broken is +1646/4 = 411.5 kJ mol−1.

**(c) (i)** Bonds broken (610 + 1640 + 436) = +2686 **✓**

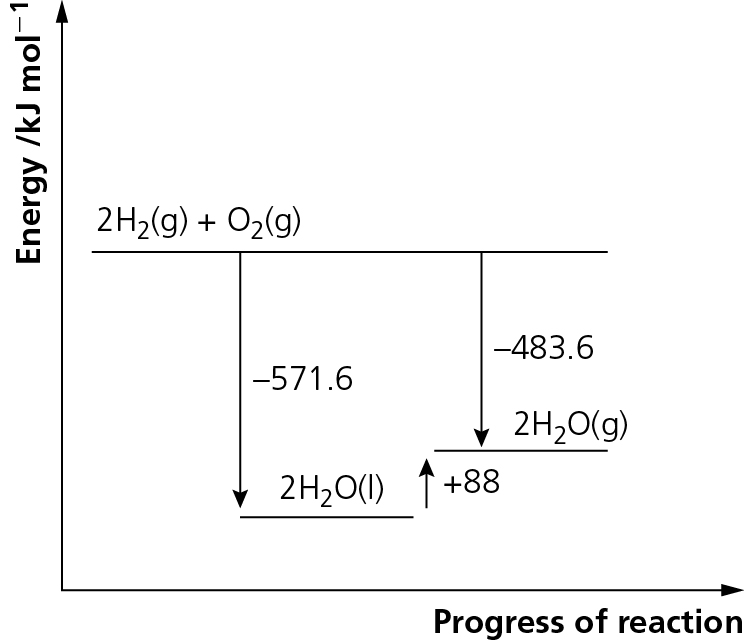
Bonds formed (–350 – 2460) = −2810 **✓**

Enthalpy change = −124 kJ mol−1 **✓**

**(ii)** The bond energies used in the calculation are average values **✓** for the bonds, such that the C−H bond in ethene and ethane were assumed to be the same when in fact the C−H bond enthalpies will be different because they are in different environments **✓**.

**(d)** The Ni catalyst is a heterogeneous catalyst, which speeds up a reaction without being used up. The ethene and hydrogen gases are adsorbed onto the surface of the Ni **✓**, bonds are weakened (activation energy is lowered) **✓**, the reaction takes place and the ethane is desorbed **✓**.

**2 (a)**

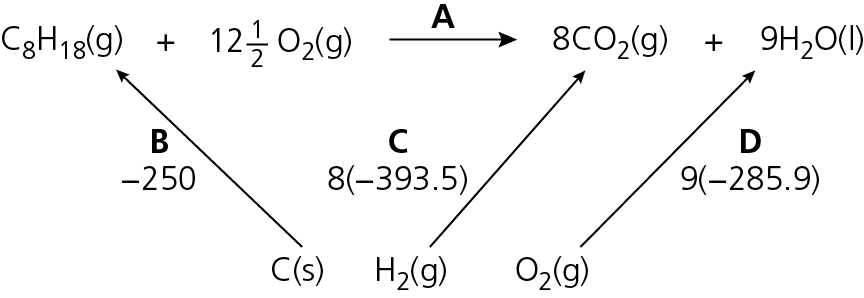
**✓✓**

**(b)** From the diagram: 2H2O(l) → 2H2O(g) *H* = +88 kJ mol−1 **✓**

Hence: H2O(l) → H2O(g) *H* = +44 kJ mol−1 **✓**

**3 (a)** It is the enthalpy change when 1 mole **✓** of a substance is burnt completely, in an excess of oxygen **✓**, under standard conditions of 298 K and 101 kPa (1 atmosphere) **✓**.

**(b)**



A + B = C + D

A = C + D – B

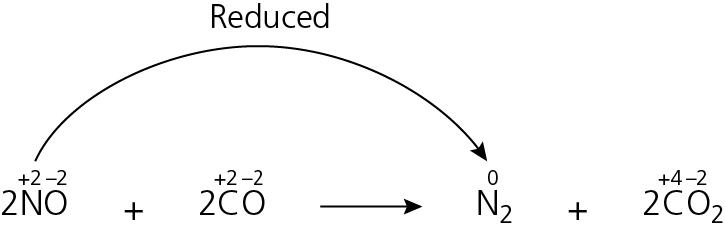
= (−3148) + (−2573.1) − (−250)**✓✓** = −3148 + 2573.1 + 250 = −5471.1 kJ mol−1 **✓**

**(c)** C8H18(l) + 8½O2(g) → 8CO(g) + 9H2O(l) ✓

N2(g) + O2(g) → 2NO(g) ✓

**(d) (i)** 2NO(g) + 2CO(g) → N2(g) + 2CO2(g) **✓**

**(ii)**



Nitrogen **✓** has been reduced because its oxidation state has changed from +2 to zero **✓**.

**4 (a)** The rate of both forward and reverse reactions are the same **✓** and, therefore, the amount of each chemical remains the same (even though they are constantly interchanging)**✓**.

**(b) (i)** The position of the equilibrium moves to the left **✓** because it favours the reverse reaction, which is endothermic **✓**.

**(ii)** The equilibrium moves to the right **✓** because there are fewer molecules of gas on the right-hand side **✓**.

**(iii)** Low temperature (because the forward reaction is exothermic) **✓** and high pressure (because there are fewer moles of gas on the right) **✓**.

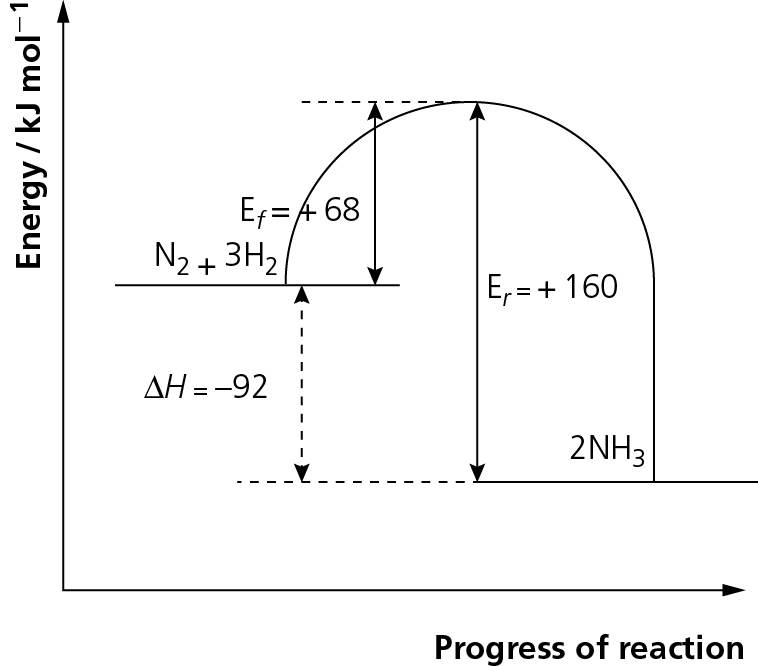
**(c) (i)** Temperature: a compromise is reached between rate and conversion. **✓** At low temperature the rate is too slow and therefore a higher temperature is used even though the percentage conversion is lower. **✓**

Pressure: a compromise is reached between cost and conversion. A moderate pressure is used even though the percentage conversion is lower (also the rate is slower) because high pressure increases cost and decreases safety. **✓**

**(ii)** The catalyst speeds up the reaction but doesn’t change the equilibrium position **✓** because it speeds up the forward and the reverse reactions equally, so the percentage conversion is the same **✓**.

**(iii)** More cost efficient/less waste **✓** and reduces the amount of SO2 pollution **✓**.

**5 (a) (i)** The marking points are: products at a lower enthalpy than the reactants**✓**; activation energy of forward reaction correctly labelled**✓**; activation energy of reverse reaction correctly labelled **✓**



**(ii)** Activation energy is the *minimum* energy required to start a reaction. **✓**

**(iii)** −92 kJ mol−1 **✓**

**(b) (i)** The N in NH3 is −3 **✓** and the N in HNO3 is +5 **✓**. An increase in oxidation number involves a loss of electrons, which is oxidation (OILRIG). **✓**

**(ii)** Le Chatelier’s principle states that if a closed system under equilibrium is subject to a change, the system will move in such a way as to minimise the effect of the change. **✓**

**(iii)** Temperature: the forward reaction is exothermic **✓** and so will be favoured by low temperature **✓**.

Pressure: there are more moles of gas on the right **✓**so if a low pressure **✓** is used the system moves to the right.

**(iv)** Re-used/recycled in stage 2 **✓**

**(c)** Acids are proton/H+ donors**✓**; HNO3 is a strong acid because it completely dissociates **✓** into its ions:

HNO3 → H+ + NO3− **✓**

**6 (a)** The marking points are:

* use the equation *Q* = −*mc*Δ*T* **✓**
* mass = 150 **✓**
* calculate value of *Q* **✓**
* moles of ethanol **✓**
* divide value of Δ*H* by moles of ethanol **✓**
* correct units **✓**

Δ*H* = −*mc*Δ*T*

moles of ethanol = 1.6/46 = 0.0347826087 = −(150 × 4.2 × 49)

Δ*H* = −30.87/0.0347826087 = −30870 J = −30.87 kJ

= −887.5125 = 888 (to 3 s.f.) kJ mol−1

It is important in any calculation not to round during the calculation and *only* round at the end.

**(b)** Heat loss is the most significant error **✓**, which could be improved by lagging the apparatus. Incomplete combustion **✓**— CO or C may have been formed **✓**, which could be reduced by increasing the supply of oxygen to ensure that CO2 is always produced **✓**.

(There are 2 marks for the errors and 1 mark for either improvement.)

Students often criticise apparatus without carefully considering the error. Given that the temperature rise was approximately 50°C, if the thermometer used measured to the nearest degree, then the percentage error in measuring the temperature rise would be of the order (1/50) × 100 = 2%. Given the inaccuracy of the experiment this is not a significant error.

**(c)** There are many examples that could be used. The mark scheme shown below would be applied to all answers. The marking points are:

* Identification of a suitable example of a homogeneous catalyst. **✓** Suitable use for product. **✓**
* Identification of a suitable example of a heterogeneous catalyst. **✓** Suitable use for product. **✓**

Any two from:

Catalysts lower activation energy. **✓** Catalysts reduce costs because less energy is required. **✓**

Catalysts are not used up and so can be used again. **✓**

**7 (a)** the equilibrium mixture would turn from orange to red **✓** because by adding an acid the H+(aq) concentration on the left-hand side is increased, so the equilibrium moves to the right to minimise the effect of the added H+(aq)**✓**

**(b)** The mixture would turn orange **✓** and then red **✓** because by adding an acid the OH−(aq) reacts with the H+(aq) on the left-hand side **✓** and decreases the concentration; the equilibrium moves to the left to minimise the effect of the added OH−(aq)**✓**