Cross topic exam-style questions

DP exam questions may be topic-specific or refer to content from across different topics. These questions explore the links between various concepts, as well as aspects of NOS and the skills in the study of chemistry.

Below, three exam-style questions have been annotated to show their links to different parts of the course. Next time you do an exam-style question, try to link it to the various course topics, NOS and skills as shown below.

The enhanced greenhouse effect and ozone-layer depletion are two separate atmospheric problems.

Nitrous oxide, N_2O, and carbon dioxide, CO_2, are greenhouse gases. Chlorofluorocarbons (CFCs) are also greenhouse gases, but they are primarily known for their ozone-depleting properties.

Question 1

a. Nitrous oxide, N_2O, is a greenhouse gas.

i. Draw a possible Lewis formula of N_2O, nitrous oxide. [2] ← Structure 2.2 Lewis formulas

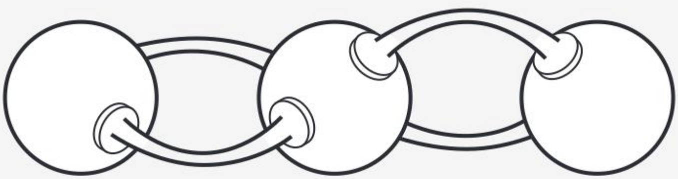
ii. State and explain the molecular geometry of nitrous oxide. [2] ← Structure 2.2 VSEPR

iii. Explain why nitrous oxide is IR active. [2] ← Structure 3.2 IR spectroscopy

iv. Deduce the formal charge of each of the atoms in nitrous oxide. [1] ← Structure 2.2 AHL Formal charge

AHL

b. Carbon dioxide is a greenhouse gas. An image of a molecular model of carbon dioxide is shown below:



Describe one strength and one limitation of this model's representation of the bonding in carbon dioxide molecules. [2] ← NOS – models

Question 2

a. Carbon dioxide is produced in the complete combustion of organic compounds such as alcohols.

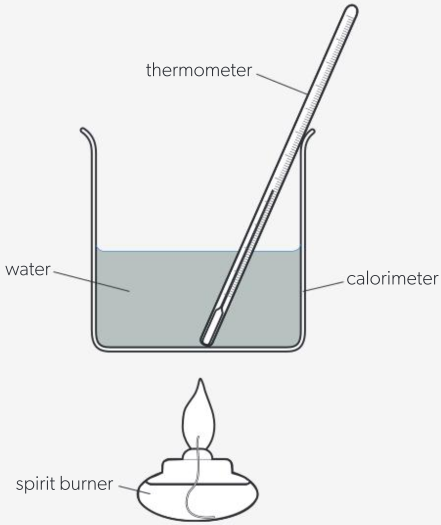
i. State the balanced equation for the combustion of propan-1-ol. [1] ← Reactivity 1.3 Fuels

ii. Determine the molar enthalpy of combustion of propan-1-ol from bond enthalpy data. [3]

iii. Explain why the value you obtained above differs from the standard enthalpy of combustion of propan-1-ol, which is $-2021\ kJ\ mol^{-1}$. [1]

Reactivity 1.2 Energy cycles

b. A student determines the enthalpy of combustion of propan-1-ol by calorimetry using the apparatus shown below:



i. Outline the experimental method employed by the student, identifying the necessary measurements. [3] ← Tool 1: Experimental techniques – calorimetry

ii. The student's experimental enthalpy of combustion of propan-1-ol was $-894\ kJ\ mol^{-1}$. Calculate the percentage error. [1] ← Tool 3: Mathematical skills – percentage error

iii. Predict, giving a reason, the sign of the entropy change for the combustion of propan-1-ol. [1]

iv. The standard entropies of propan-1-ol and oxygen are $193\ J\ K^{-1}\ mol^{-1}$ and $205\ J\ K^{-1}\ mol^{-1}$, respectively. Further standard entropy values are listed in section 13 of the data booklet. Using these data, determine the standard entropy change for the combustion of propan-1-ol, in $J\ K^{-1}\ mol^{-1}$. [1]

v. Determine the Gibbs energy for the combustion of propan-1-ol at 298 K. Give your answer in $kJ\ mol^{-1}$. [2]

Reactivity 1.4 AHL Entropy and spontaneity

AHL

Question 3

Ozone is a gas found in the upper atmosphere which absorbs harmful UV radiation from the Sun. The following mechanism has been proposed to describe the depletion of ozone:

Step 1 $O_3 + Cl\bullet \rightarrow ClO\bullet + O_2$

Step 2 $ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$

a. A student describes Cl• as a "chloride anion". Outline the student's mistake and suggest the correct term. [2]

← Reactivity 3.3 Radicals

b. Identify, giving a reason, the species in the mechanism that is a catalyst. [1]

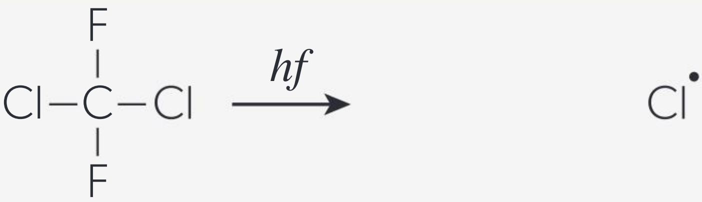
← Reactivity 2.2 Catalysts

c. The rate equation for the reaction is found to be rate = $k[O_3][Cl\bullet]$. Identify, giving a reason, which step in the mechanism is likely to be the rate determining step. [1]

← Reactivity 2.2 AHL Rate equations

d. Chlorofluorocarbons (CFCs) such as CF_2Cl_2 are sources of Cl• when exposed to certain wavelengths of electromagnetic radiation. Complete the diagram below to show the formation of a Cl• species from a CF_2Cl_2 molecule. Include fish-hook arrows and the structural formula of the missing species. [2]

← Reactivity 3.3 Electron sharing reactions



e. CFCs are ozone-depleting substances used as refrigerants. Hydrofluoroolefins, HFOs, are unsaturated organic compounds with the potential to replace CFCs in their application as refrigerants. Since HFOs are more reactive than CFCs, they decompose faster and have shorter lifetimes in the atmosphere. An example of a HFO is 2,3,3,3-tetrafluoropropene.

i. Draw the skeletal structure of 2,3,3,3-tetrafluoropropene. [2]

← Structure 3.2 Representation of organic compounds

ii. Suggest why HFOs are more reactive than CFCs. [1]

↑ Reactivity 3.4 Reactivity of alkenes

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