Obtaining energy from fuel

definition of fuel, origin & renewability. Combustion of fuel, energy transformations, efficiency, enthalpy change

Definitions: fuel _____ renewability _____

Fuel	Origin	Renewable	Energy transformations	Efficiency	kJ.g^{-1}	kJ.mol^{-1}	MJ/tonne
coal							
natural gas							
biogas							
petrol							
LPG							
bioethanol							
petrodiesel							
biodiesel							

write balanced thermochemical equations for complete & incomplete combustion of hydrocarbons, methanol and ethanol

Fuel	complete combustion	incomplete combustion
methane		
ethane		
methanol		
ethanol		

1. What is the difference between a non-renewable and a renewable fuel? (non-renewable p3, renewable p8).

2. Where did the chemical energy in fossil fuels originate from? (p3)

3. Black coal is a non-renewable energy, with a higher heat of combustion than brown coal. Give reasons for these observations. (p4)

4. Explain why a gas-fired plant has 40% efficiency while the efficiency of a coal-fired power station can be as low as 30%. (p12,13)

5. Explain why the energy released in the combustion of 1 g of ethanol is 62% of petrol. (p16)

the writing of balanced thermochemical equations, including states, for the complete and incomplete combustion of hydrocarbons, methanol and ethanol, using experimental data and data tables

6. Provide an explanation for why the heat of combustion of methanol in the first thermochemical equation differs to the second. (p42)

$2CH_3OH(l) + 3O_{2(g)} \rightarrow CO_{2(g)} + 4H_2O(l)$ $\Delta H = -1452$ kJ.mol^{-1} Eqn 1

$3CH_3OH(l) + 4\ 1/2\ O_{2(g)} \rightarrow 3CO_{2(g)} + 6H_2O(l)$ $\Delta H = -2178$ kJ.mol^{-1} Eqn 2

7. When a Bunsen burner is lit the flame is yellow and leaves black soot on the outside of a container. Give the equation for this reaction and explain how a cleaner burning flame could be achieved. (p47)

8. Explain why water is written in the liquid state in a thermochemical equation for the heat of combustion of a fuel. (p50)

9. Explain why it is not possible to determine the heat of combustion in kJ.mol^{-1} for petrol and petrodiesel.

the definition of gas pressure including units, the universal gas equation and standard laboratory conditions (SLC) at 25 °C and 100 kPa $\boldsymbol{PV = nRT}$ $\boldsymbol{n = \frac{V}{Vm}}$

10. How many moles of carbon dioxide are generated when 12 moles of butane are burned completely in oxygen?

11. Calculate the volume of carbon dioxide, in L, produced when 1.50 kg of methane is burned completely in oxygen. The gas volume is measured at SLC.

calculations related to the combustion of fuels including use of stoichiometry in calculations of enthalpy change to determine heat energy released, reactant and product amounts and net volume of greenhouse gases at a given temperature and pressure released per MJ of energy obtained

12. Calculate the heat energy released, in MJ, when 12.0 kg of octane undergoes complete combustion.

$2C_8H_{18(l)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(l)}$ $\Delta H = -10900$ kJ mol^{-1}

13. Calculate volume of CO2 produced per kg of ethanol when it undergoes complete combustion at SLC. (p93 – 95)

Obtaining energy from fuel cont.

use of specific heat capacity of water to determine the approximate amount of heat energy released in the combustion of a fuel

14. The thermochemical equation for combustion of CH_4 is:

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$ $\Delta H = -802.4$ kJ.mol^{-1}

What is the final temperature of 1000 g water, initially at 20.0°C, if it is heated by burning 0.600 g methane?

15. Methanol, 0.355 g, underwent complete combustion in a spirit burner and was used to heat 100 mL of water. The temperature of the water rose from 20.24°C to 37.65°C. Calculate the heat of combustion of methanol in kJ.mol^{-1}.

Fuel choices

the comparison of fossil fuels (coal, crude oil, petroleum gas, coal seam gas) and biofuels (biogas, bioethanol, biodiesel) with reference to energy content, renewability and environmental impacts related to sourcing and combustion

16.Explain why bioethanol, a renewable energy source, is not carbon neutral and in fact makes the same contribution of carbon dioxide emissions per megajoule of energy produced as petrol. (p18)

17.The combustion of natural gas emits 27% less carbon dioxide per megajoule of energy produced than petrol and has a similar kilojoule per gram energy content. Yet only a small percentage of cars run on LPG in Australia. Explain this discrepancy. (p16-18)

18.Coal seam gas is a major component in the energy supplies of Queensland. Explain why it is a non-renewable energy source, and yet is a preferred fuel source over biogas. (p6 and p9)

19.Explain why biofuels are renewable by referring to the origin of the three main biofuels, biogas, bioethanol and biodiesel. (p8-10)

the comparison of the suitability of petrodiesel and biodiesel as transport fuels with reference to sources, chemical structures, combustion products, flow along fuel lines (implications of hygroscopic properties and impact of outside temperature on viscosity) and the environmental impacts associated with their extraction and production

	Chemical structure	Bonding	Combustion products	Viscosity & flow along fuel lines	Energy content & energy density
petrodiesel					
biodiesel					

20.The viscosity of biodiesel is almost double that of petrodiesel. Explain this difference by referring to the difference in intermolecular bonding.

21.Discuss the effect of temperature on viscosity and the implications for the use of biodiesel as a transport fuel. (p27)

22. Biodiesel currently makes up 7% of the worlds diesel consumption, but is expected to rise to 14% by 2020. Discuss the advantages and disadvantages of this change in terms of the environmental impacts. (p29)

Galvanic Cells

redox reactions with reference to electron transfer, reduction and oxidation reactions, reducing and oxidising agents, and use of oxidation numbers to identify conjugate reducing and oxidising agents

23. Complete the mnemonic for redox reactions.

O I L R I G

24. Complete the rules for determining oxidation numbers.

a. free elements – ON =
b. monoatomic ions – ON =
c. list the fixed ON =
d. calculation of ON for polyatomic ions -

25. Determine the oxidation number of the elements in bold. a. $\mathbf{Al}_2O_3$ b. $\mathbf{Cr}_2O_7^{2-}$

26. Assign oxidation numbers to the following reaction, and hence determine whether it is a redox reaction.

$2CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (l)$

the writing of balanced half-equations for oxidation and reduction reactions and balanced ionic equations, including states, for overall redox reactions

27. Complete the mnemonic for complex redox reactions.

K O H E S

28. Write the half equations and the overall equation for the reaction between permanganate ions and ethanol. The skeletal equations are: $MnO_4^- \rightarrow Mn^{2+}$, $C_2H_5OH \rightarrow CH_3COOH$

galvanic cells as primary cells and as portable or fixed chemical energy storage devices that can produce electricity including common design features (anode, cathode, electrolytes, salt bridge and separation of half-cells) and chemical processes (electron and ion flows, half-equations and overall equations)

28. Draw a representation of the following galvanic cell; a. Ag/Ag$^+$ and Ni/Ni^{2+}. Write the half equations and overall equations and label the anode, cathode, direction of election flow and ion movement in the salt bridge. List any visible changes which would take place in the cells.

the comparison of the energy transformations occurring in spontaneous exothermic redox reactions involving direct contact between reactants (chemical energy to heat energy) compared with those occurring when the reactants are separated in galvanic cells (chemical energy to electrical energy)

29. Write the half-cell equations and overall equation for the exothermic redox reaction between zinc and oxygen. Identify the energy transformation that occurs during this reaction.

30. Compare the reaction in Q29 with the galvanic cell with half cells, Zn/Zn^{2+} and O2/OH$^-$. Write the half equations, overall equation and identify the energy transformation that occurs.

the use of the electrochemical series in designing and constructing galvanic cells and as a tool for predicting the products of redox reactions, deducing overall equations from redox half-equations and determining maximum cell voltage under standard conditions

31. What half cells could you use to build a battery with a maximum cell potential of 2.12 V?

32. Predict the products of mixing the reactants a. $Cu^{2+}_{(aq)}$ with $Mg_{(s)}$ and b. $B2_{(l)}$ with $Fe_{(s)}$

Fuel cells

common design features of fuel cells including use of porous electrodes for gaseous reactants to increase cell efficiency

33. Draw a diagram of an alkaline fuel cell which requires inputs of H2 and O2 gas. (p153) Label the anode, cathode, reactants, products and electrolyte. Write the half-equations for the reactions occurring at the anode and cathode.

comparison of the use of fuel cells and combustion of fuels to supply energy with reference to their energy efficiencies, safety, fuel supply (including storage of H_2), production of greenhouse gases and applications

35. Methanol can be used in a fuel cell to generate electrical energy or combusted to produce heat energy. Compare the chemical reactions, the energy efficiencies and safety of these two processes. (p154, 159)

36. Discuss the advantages and limitations of using hydrogen as a fuel source. (p156)

comparison of fuel cells and galvanic cells with reference to their definitions, functions, design features, energy transformations, energy efficiencies and applications

35. Complete the table to compare fuel cells with galvanic cells.

	fuel cell	galvanic cell
definition		
design features		
energy transformation		
energy efficiency		
applications: example cells		

Unit 3 AOS1 summary

CHEM TopUp Tools

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