Attainment Targets VWO Chemistry

Subdomain A10: Application of chemical concepts

Target: The candidate can recognize and relate physical and biological concepts used in chemistry.

Specification

1. The candidate can recognize and use the following chemical concepts:
    - aggregation state / phase
        - phase indicators (s), (l), (g) and (aq)
    - alcohols
    - ammonia
    - atomic mass unit (u)
    - greenhouse effect
    - carboxylic acids
    - coefficient
    - distillate
    - explosion
    - extraction agent
    - phase transition
    - filtrate
    - index
    - indicator
    - mobile phase
    - stationary phase
    - lye / caustic soda
    - ignition temperature
    - decomposition reaction: electrolysis, photolysis and thermolysis
    - incomplete combustion
    - solvent
    - reagent
    - residue
    - titration
    - trivial name
    - calibration line
    - muriatic acid
2. The candidate can recognize and use the following biological concepts:
    - respiration
    - blood
    - cell
    - cell membrane
    - chromosome
    - ecosystem

- heredity
- organism
- digestion
- transport

3. The candidate can recognize and use the following physics concepts:
   - pressure
   - energy
   - force
   - light
   - mass
   - radioactivity
   - power
   - radiation
   - current
   - temperature
   - heat

Subdomain B1: Particle models

Target: The candidate can describe and use particle models.

Specification

1. The candidate can describe the structure of atoms, radicals and ions using an atomic model of the nucleus and electron cloud, using the following concepts:
   - the structure of the nucleus
     - protons, neutrons
     - atomic mass, atomic number
     - isotopes
   - structure of the electron cloud
     - shells (K, L, M, ….)
     - the maximum number of electrons in K-, L-, M-shells
2. The candidate can describe the structure of the periodic table, and thereby:
   - indicate the relationship between atomic number and position in the periodic table;
   - describe the change of properties of elements in a group;
   - globally indicate the distribution of metals and non-metals

- indicate the location of alkali metals, rare earth metals, halogens and noble gases.

3. The candidate can use the structure of the periodic table to describe the structure of the electron cloud and can:
   - indicate how characteristics of groups are related to the structure of the electron cloud;
   - indicate how the valence of the atom type is related to the structure of the electron cloud:
     - valency
     - co-valency
     - octet rule
     - valence electrons
4. The candidate can use the symbol of the following non-metals if the name is given and vice versa:
   - argon, boron, bromine, chlorine, fluorine, phosphorus, helium, iodine, carbon, neon, silicon, nitrogen, hydrogen, oxygen, sulfur.

5 The candidate can use the symbol of the following metals if the name is given and vice versa:
   - aluminum, barium, cadmium, calcium, chromium, gold, iron, potassium, cobalt, copper, mercury, lithium, lead, manganese, magnesium, sodium, nickel, platinum, tin, uranium, silver, zinc.

6 The candidate can use the (molecular) formulas of the following substances if the name is given and vice versa:
   - ammonia, acetic acid, phosphoric acid, glucose, carbon dioxide, carbon monoxide, nitric acid, nitrogen dioxide, nitric oxide, water, hydrogen chloride, hydrogen peroxide, sulfur dioxide, sulfur trioxide, sulfuric acid;
   - the formulas of non-decomposable substances:
     - non-metals
     - metals
   - the first 10 alkanes

7 The candidate can give and use the systematic IUPAC names and ratio formulas of salts composed of the following ions:

- Ag^{+}, Al^{3+}, Au^{+}, Au^{3+}, Ba^{2+}, Ca^{2+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Hg^{+}, Hg^{2+}, K^{+}, Li^{+}, Mg^{2+}, Na^{+}, NH_4^{+}, Pb^{2+}, Pb^{4+}, Sn^{2+}, Sn^{4+}, U^{3+}, U^{6+}, Zn^{2+}, Br^{-}, CH_3COO^{-}, Cl^{-}, CO_3^{2-}, F^{-}, HCO_3^{-}, I^{-}, MnO_4^{-}, NO_3^{-}, NO_2^{-}, O^{2-}, OH^{-}, PO_4^{3-}, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_3^{2-}$.

8 The candidate can recognize the following acids:

- HCl, H_2SO_4, HNO_3, $H_2O + CO_2$ / 'H_2CO_3', H_3PO_4, CH_3COOH.

9 The candidate can recognize the following bases:

- NH_3, OH^{-}, CO_3^{2-}, O^{2-}, HCO_3^{-}

10 The candidate can give the ratio formula of a salt based on given ions and give the systematic IUPAC name and vice versa.

11 The candidate can recognize water of hydration in the given formula of a hydrate (notation .n H_2O).

12 The candidate can give a Lewis structure of a given molecular formula, formula of (compound) ions or structural formula:

- mesomery
- boundary structures

13 The candidate can indicate the position of formal and partial charges in a (Lewis) structural formula.

14 The candidate can indicate that the molecular formulas of different organic compounds can be identical to each other:

- structural isomery

15 The candidate can recognize functional / characteristic groups in molecules of organic compounds:

- C=C
- C≡C
- OH group (hydroxyl)
- C=O (aldehyde and keto)
- COOH group (carboxyl)
- NH_2 group (amino)
- COC group (ether)

- COOC group (ester)
- CONHC group (peptide, amide)
- C-X (in which X= F, Cl, Br, I)

16 The candidate can assign the systematic IUPAC name with the structural formula of carbon compounds with a branched or unbranched carbon chain with a maximum of 10 carbon atoms with at most two types of functional / characteristic groups and vice versa:

- alkanes
- alkenes
- alkynes
- alkanols
- alkanals
- alkanones
- alkanoic acids
- alkane amines
- halogen alkanes
- cycloalkanes
- cycloalkenes
- benzene and benzene derivatives
- alkoxyalkanes
- alkylalkanoates

Subdomain B2: properties and particle models

Target: The candidate can explain macroscopic properties of substances and materials by particle models from annotated research.

Specification

1. The candidate can indicate what is meant by substances and materials in chemistry and thus reason and use the following concept:
   - substance properties

2. The candidate can make a connection between:
    - a pure substance and melting point / boiling point
    - a mixture and melting range / boiling range
3. The candidate can describe the difference between pure substances and mixtures at the micro level.
4. The candidate can describe the difference between decomposable and non-decomposable substances at the micro level.
5. The candidate can describe the difference between a molecular substance and a salt at the micro level.
6. The candidate can use the following terms in reasoning about mixtures:
    - solutions: saturated and non-saturated
    - suspension
    - emulsions, emulsifier
    - alloys
    - homogeneous and heterogeneous mixtures

Subdomain B3: Chemical bonds and characteristics

Target: The candidate can explain properties of substances and materials with the help of knowledge about bonds in and between particles.

Specification

1. The candidate can describe the lattice structure, also making use of the bonds between the constituent particles:
    - metal lattice
        - metal bonds
    - ionic lattice
        - ionic bonds
    - molecular lattice

        - molecular bonds / van der Waals bonds
        - dipole-dipole bonds
        - hydrogen bonds
    - atomic lattice
        - atomic bonds / covalent bonds

2. In a given example, the candidate can explain that intermediate forms of the lattices mentioned in B3.1 are also possible.
3. The candidate can identify and describe:
    - atomic bonds / covalent bonds
        - shared electron pairs
    - polar atomic bonds
        - bonds of N, O, or F to other atoms by which a partial negative charge resides on N, O or F.
    - ionic bonds
4. The candidate can relate the strength of the bond between the constituent particles of a substance / substances to phase transitions and adhesion to a surface:
    - ionic bonds
    - van der Waals bonds / molecular bonds
    - hydrogen bonds
    - dipole-dipole bonds
    - metal bonds
5. The candidate can relate differences in solubility / miscibility to concepts of hydrophobic / hydrophilic properties.
6. The candidate can relate the terms hydrophobic / hydrophilic to:
    - van der Waals bond, dipole-dipole bond and hydrogen bond
    - polar and non-polar
7. The candidate can relate the practical application of a salt to the solubility of that salt.

Subdomain B4: Bonds, structures and characteristics

Target: The candidate can explain properties of substances and materials on the basis of knowledge of structures and the bonds in and between particles and, conversely, predict properties of substances from the structures of substances or materials.

Specification

1. The candidate can make a connection between the make up of a substance and
    - electrical conductivity, by considering:
        - the presence and mobility of charged particles:
            - electrons
            - ions
    - deformability, by considering:
        - make up of a lattice
        - presence of plasticizers
        - structure of polymer materials:
            - thermoplastic polymers
            - thermosetting polymers
    - UV sensitivity, by considering:
        - the presence of double and triple bonds
        - formation of cross links
        - sensitivity to corrosion, by considering:
            - standard electrode potential (nobility of metals)
            - presence of a coating
2. For composites, polymers, alloys and ceramic materials, the candidate can make a connection between the structure / spatial organization of constituents particles and the following properties:
    - deformability
    - electrical conductance

- water binding capacity
- sensitivity to corrosion
- sensitivity to UV-light
- flammability
- hardness
- brittleness

3. The candidate can indicate the spatial make up of compound ions and molecules, or parts thereof, using the Valence-Shell-Electron-Pair-Repulsion Theory (VSEPR theory):
   - coordination number 2, 3 and 4
   - 4 coordination: tetrahedral coordination with bond angles of 109°
   - 3 coordination: trigonal coordination with bond angles of 120°
   - 2 coordination: linear coordination with bond angle of 180°
4. The candidate can conclude from the spatial structure of a molecule, using the charge distribution within the molecule, whether the particle has a dipole.

Subdomain C1: Chemical processes

Target: The candidate can describe chemical reactions and physical processes in terms of reactivity and the formation and breaking of (chemical) bonds.

Specification

1. The candidate can describe which types of bonds are broken and/or are formed when substance dissolves in water:
   - molecular substances
   - salts
     - ion-dipole bond, hydration
2. The candidate can describe which types of bonds are broken and/or are formed when dissolving and ionizing in water:

- acids:
  - oxonium ion
- bases

3. The candidate can describe which types of bonds are broken / formed for the following processes:
   - evaporation
   - condensation
   - melting
   - solidification
4. The candidate can give a (reaction) equation of the above processes (C1.1 to C1.3).
5. The candidate can describe which bonds are broken / formed in the following separation processes, and partly on the basis of this indicate how the separation occurs:
   - distillation
   - adsorption
6. The candidate can give a reaction equation of the following processes:
   - complete combustion of carbon compounds, hydrogen and possibly oxygen
   - processes of which reactants and products are known
7. The candidate can describe donor / acceptor reactions as reactions in which a particle is transferred and can thereby indicate which particle is the donor and which the acceptor is:
   - acid/base reaction, transfer of protons
   - redox reactions, transfer of electrons
8. void
9. The candidate can describe what is meant by electrolysis
   - charging batteries
   - deposition of metal coatings
   - oxygen/hydrogen generation
10. The candidate can indicate the difference between strong and weak acids
11. The candidate can setup reaction equations between acids and bases

12. The candidate can describe what buffer systems are and can indicate how they work.
13. The candidate can indicate the relative strength of a reducing agent or oxidizing agent using the standard electrode potential.
14. The candidate can setup half reactions in the context of batteries / fuel cells if the redox couple is given.
15. The candidate can give a reaction equation of a redox reaction using given half reactions.
16. The candidate can indicate in organic-chemical reactions which bonds are broken and/or formed, and if necessary make use of boundary structures:
    - condensation reactions
      - esters
      - peptide/amide
    - addition reactions to double bonds
      - C=C
      - 1,2 and 1,4 addition
17. For organic-chemical reactions the candidate can give the reaction equation in structural formulas and Lewis structures:
    - condensation reactions
      - esters
      - peptide/amide
    - hydrolysis reactions
    - addition reactions
    - substitution reactions
18. The candidate can describe a reaction with analogous compounds on the basis of a given reaction.

Subdomain C2: Chemical calculations

Target: The candidate can make calculations about processes with the help of knowledge of chemical reactions and laws of conservation.

Specification

1. The candidate can use the following concepts in calculations:
    - mass
        - symbol *m*
        - unit kg
    - volume
        - symbol *V*
        - unit m^3
    - relative molecular mass
        - symbol M_r
    - chemical amount
        - symbol *n*
        - unit mol
    - molar mass
        - symbol *M*
        - unit g mol^{-1}
    - molar volume
        - symbol V_m
        - unit m^3 mol^{-1} or L mol^{-1}
    - density
        - symbol ρ
        - unit kg m^{-3}
    - concentration
        - symbol *c(X)* or [X]
        - unit mol L^{-1}
    - mass percentage
        - unit %

- mass ppm
  - unit ppm, mg kg^{-1}
- mass ppb
  - unit ppb, μg kg^{-1}
- volume percentage
  - unit %
- volume ppm
  - unit ppm, μL L^{-1}, cm3 m^{-3}
- acidity
  - symbol pH
    - pH = -log[H^+]; pH = -log[H_3O^+]
    - pOH = -log[OH^-]
    - pH + pOH = 14 (at 298 K)
    - [H^+] = 10^{-pH}; [H_3O^+] = 10^{-pH}
    - [OH^-] = 10^{-pOH}

2. The candidate can use the following principles in calculations and descriptions of chemical processes:
   - mass ratio
   - volume ratio of gases is reactions
   - limiting agent / access agent
   - stoichiometric ratio (mol ratio)
   - yield as fraction or percentage of the theoretical yield

Subdomain C3: Laws of conservation and cycles

Target: The candidate can make links between laws of conservation and chemical processes, and can relate these links to substance (elemental) cycles.

Specification

1. The candidate can use the following concepts in reasoning:
    - conservation of mass / mass balance
    - conservation of energy / energy balance
    - conservation of charge / charge balance
2. The candidate can relate chemical processes to:
    - substance cycle
    - elemental cycle
    - recycling
    - cradle to cradle

Subdomain C4: Reaction kinetics

Target: The candidate can analyze chemical processes on the basis of knowledge of reaction kinetics, for example by calculating the concentration of substances and particles present, and can indicate the role of catalysis.

Specification

1. The candidate can explain changes in reaction speed with the colliding particle model and use the following concepts:
    - reaction surface
    - concentration
    - temperature
2. The candidate can explain changes in reaction speed using the following concepts:
    - catalyst
    - activation energy
3. The candidate can indicate that reactions often go in a number of steps:
    - reaction mechanism

- rate determining step

4. Using reaction data the candidate can calculate the reaction rate in mol $L^{-1}s^{-1}$.
5. The candidate can give a description of the displacement of electrons / electron pairs of a given reaction mechanism:
   - nucleophylic, electrophylic
   - radicals
   - boundary structures

Subdomain C5: Chemical equilibrium

Target: The candidate can indicate whether there is a chemical equilibrium, can perform calculations on chemical equilibria, and can explain how the position of chemical equilibria can be influenced.

Specifications

1. The candidate can use the following terms when describing chemical processes:
   - reactions that run to completion
   - reversible reactions
   - equilibrium
2. The candidate can give the equilibrium condition for a given equilibrium and can perform equilibrium calculations:
   - reaction quotient
   - equilibrium constant K_c
   - K_a, K_b, K_w
3. The candidate can explain a change in equilibrium on the basis of:
   - change in the reaction quotient
   - change of the equilibrium constant
4. The candidate can explain the influence of a catalyst on a chemical process:

- reaction rate
- setting time of an equilibrium
- position of an equilibrium

5. The candidate can calculate the pH of a solution with a known concentration of an acid or of a base or, conversely, calculate the concentration (molarity) from the pH.
   - strong acid
   - monoprotic weak acid
   - strong base
   - monoprotic weak base

Subdomain C6: Energy calculations

Target: The candidate can make calculations about energy conversions and energy exchange in chemical processes and draw conclusions and formulate proposals.

Specification

1. The candidate can give an energy diagram, indicate the energy effect of a reaction and make use of:
   - transition state / activated state
   - role of a catalyst
2. The candidate can use the following concepts and thereby reason about energy conversions in chemical processes:
   - endothermic, exothermic
   - heat of formation, enthalpy of formation
   - activation energy
   - energy diagram
3. The candidate can calculate the reaction heat of a reaction with the help of heats of formation.

4. The candidate can calculate and reason using the first law of thermodynamics (law of conservation of energy):
    - conversion of chemical energy to other forms of energy
        - heat
        - electrical energy

Subdomain D1: Chemical techniques

Target: Using knowledge of materials and substances, the candidate can formulate and assess a choice for a specific separation and / or analysis method.

Specification

1. For separation methods, the candidate can explain which difference in (substance) property they are based on and explain why they are used in a certain process:
    - filtration
    - centrifugation
    - distillation
    - extraction / washing
    - adsorption
    - deposition
    - forced evaporation
2. The candidate can explain how analysis methods are used to check whether and to what extent a separation method has been successful.
3. The candidate can explain on which differences in substance properties chromatography is based.
4. The candidate can indicate the presence of certain substances by means of gas chromatography using the retention time.
5. The candidate can indicate that there are characteristic patterns in mass spectra of substances indicative for recognition of a substance and can analyze mass spectra.

6. The candidate can calculate the quantity of a substance in a solution or mixture from sample results of quantitative determinations or explain a given calculation:
    - chromatography: area under a peak
    - mass spectrometry: height of a peak

Subdomain D3: Chemical synthesis

Target: With the knowledge of chemical processes, the candidate can indicate how substances are synthesized and hereby illustrate relevant reaction mechanisms.

Specification

1. The candidate can make a connection between the structural formula of a (co)polymer and the structural formula(s) of the monomer(s):
    - addition polymers
    - condensation polymers
2. The candidate can describe the various steps in the reaction mechanism of addition polymerization:
    - initiation, propagation, termination
3. The candidate can make a connection between the reaction mechanism and:
    - average chain length, degree of polymerization
    - cross links

Subdomain E1: Chemical research

Target: The candidate can reason, based on a described study within the context about issues of health, materials and food, outside the context using known within the VWO programme assumed chemical / biochemical knowledge.

Specification

1. The candidate can describe the relationship between the microstructure and macroscopic properties of substances / materials and can indicate how this relationship is used in a described study:
    - mobility of charged particles and conductivity
    - characteristic groups and reactivity
        - free electron pair
        - radical
        - double and triple atomic bonds
        - dipole / polar atomic bond
    - lattices and deformability
        - metal lattices
            - lattice faults
            - alloys
            - influence of temperature
        - lattices / polymer structures
            - plasticizers
            - chain length
            - type of monomer(s)
            - cross links
        - crystal structure of ceramics
            - ionic lattice
            - atomic lattice
    - presence of double or triple bonds and UV-sensitivity
    - type of metal atoms and sensitivity to corrosion
        - coating of metal oxide
        - standard electrode potential (nobility of metals)

- molecular structure and solubility
  - characteristic groups
  - hydrophilic / hydrophobic properties
- molecular structure and water repulsion
  - characteristic groups
- molecular structure and biodegradability of polymers
  - characteristic groups

Subdomain E2: Selectivity and specificity

Target: The candidate can explain selectivity and specificity in chemical reactions at least in the context of food production, medicines or transport of substances in the body, using knowledge of catalysis if applicable.

Specification

1. The candidate can make a connection between the make up of an (organic) molecule and the properties of a substance:
   - stereo isomery
     - cis / trans isomery
     - enantiomery
       - chiral carbon atom
2. The candidate can explain the kinetics of the reaction between enzyme and substrate when qualifying an enzyme as a biocatalyst and can use the following concepts:
   - formation of an enzyme-substrate complex
   - release of product
3. The candidate can describe the specificity and selectivity of an enzyme on the basis of the spatial structure and the functional groups:
   - active site
     - optimal pH

    - optimal temperature

4. The candidate can indicate which factors play a role in the transport of substances in the body:
    - pH
    - hydrophobic / hydrophilic properties
    - membranes

Subdomain F1: Industrial processes

Target: The candidate can describe industrial processes in block diagrams, perform calculations on them and formulate and evaluate proposals for adjustments.

Specification

1. The candidate can describe an industrial process using a block diagram:
    - substance flows
    - recirculation
    - reactors
    - separation methods
    - heat exchanger
2. The candidate can explain an industrial process on the basis of a block diagram:
    - reactions
    - separation methods
    - energy effect
    - energy maintenance
3. The candidate can use the following terms when describing an industrial process:
    - catalysis
    - continuous process
    - batch process

- bulk chemistry / fine chemistry

Subdomain F2: Sustainable (Green) chemistry

Target: The candidate can, using knowledge of process technology and reaction kinetics, at least in the context of food production or sustainability, recognize "principles of green chemistry" and relate them to realized changes, possible and desired changes to those processes and can perform simple calculations.

Specification

1. The candidate can make connections between aspects of green chemistry that have played a role in the design and adaptation of industrial processes:
   - reaction conditions
   - safety
   - qualitative energy considerations
   - side reactions
   - batch process / continuous process
   - side products
   - incomplete conversions
   - limiting / access agent
   - (renewable) crude materials
   - use of water
   - recycling
   - waste
   - environmental requirements
2. The candidate can perform calculations on a process based on given formulas from green chemistry:
   - atom economy
   - E-factor

- energy effect
- yield

Subdomain F3: Energy conversions

Target: In the context of sustainability, the candidate can describe which chemical and / or technological processes are used for energy conversions and can use this knowledge of energy production to describe these processes, and can indicate the prevailing conditions and assess proposals for adaptation.

Specification

1. The candidate can with a description of the techniques below for energy production from biomass reason about:
   - fermentation: bio-ethanol, biogas
   - production of biodiesel
   - combustion
2. void
3. The candidate can describe the photosynthesis of glucose as a process whereby light is converted into chemical energy:
   - carbon fixation
   - oxygen release
4. The candidate can compare fuels, assess proposals for adaptation(s) and reason on aspects of sustainability that play a role in:
   - difference in amount of carbon dioxide produced by biofuel and fossil fuel:
     - carbon cycle
   - C / H ratio
     - relating the amount of carbon per joule
   - other emissions in combustion
     - CO_2
     - NO_x

        - SO_2
    - side factors
        - fuel supply
        - fuel storage
        - cooling water
5. The candidate can reason about aspects of sustainability that play a role in the conversion of chemical energy into electrical energy and vice versa and can assess proposals for adaptations:
    - electrochemical cell / battery / fuel cell
        - indicate that in an electrochemical cell a redox reaction takes place where electrons are transferred through external connections
        - reducing / oxidizing agent
        - half reactions and total reaction
        - positive and negative electrode
        - electrolyte
        - membrane
        - recharging
        - recycling
        - ratio energy / mass

Subdomain G1: Chemistry of life

Target: The candidate can describe and use knowledge of chemical processes in living organisms.

Specification

1. The candidate can describe that nutrients are broken down and that the breakdown products can serve as a basis for making body-specific substances.
2. The candidate can describe the chemical structure of a number of substances:

- proteins
  - primary, secondary and tertiary structure
- carbohydrates
  - mono-, di- and polysaccharides
- fats
  - glycerol
  - fatty acids
  - saturated / unsaturated
- nucleic acids
  - DNA
    - deoxyribose
    - bases A, C, T and G
    - phosphates
  - RNA
    - ribose
    - bases A, C, U, and G
    - phosphates

3. The candidate can describe for a number of nutrients how they are broken down in the body:
   - proteins
     - hydrolysis into amino acids
     - urea
     - combustion
   - carbohydrates
     - hydrolysis into monosaccharides
     - combustion
   - fats

        - hydrolysis into glycerol and fatty acids
        - combustion

4. The candidate can describe the function of a number of substances:
    - proteins
        - support material
        - enzyme
    - carbohydrates
        - energy storage
        - glycogen
    - fats
        - energy storage
        - support material: membranes
        - phospholipids
    - nucleic acids
        - genetic code
        - protein synthesis
            - forming m-RNA
            - protein synthesis on ribosomes
            - t-RNA
5. The candidate can indicate that a limited number of substances cannot be made by the body itself and that they are therefore an essential part of the diet:
    - essential amino acids
    - essential fatty acids

Subdomain G2: Environmental effects

Target: The candidate can use knowledge of production processes to describe, at least in the

context of health or sustainability, the social conditions that play a role in environmental issues and can describe the potential consequences for health and sustainability in these issues.

Specification

1. The candidate can use information about a production process to indicate what the possible consequences for the environment and health are of that production process:
    - flow of crude materials, products and waste products
    - emission
        - boundary values
    - use of (cooling) water
    - risks at calamities
    - heat / power coupling
    - sustainability

Subdomain G3: Energy and industry

Target: The candidate can use knowledge of production processes to describe energy conversions from various sources at least in the context of sustainability. The candidate can make comparisons and give a reasoned opinion.

Specification

1. The candidate can compare different processes in the field of sustainability and argue for a choice of a particular process:
    - coal gasifier
    - gas power plant
    - coal power plant
    - fuel cell
2. The candidate can compare the use of different energy sources in a process and argue for a choice of a particular energy source:
    - hydrogen
    - bio-ethanol

- biogas
- biodiesel