Section 4

Uses of Solvents
# 9.2 Lifestyle Chemistry – Section 4 ::: Uses of Solvents

## 9.2.4 The nature of a solvent plays an important role in the application of a mixture

| 9.2.4.a | Identify water and alcohol as commonly used solvents |
| 9.2.4.b | Explain the relationship between the properties of solvents and their use in cosmetics and external medications |
| 9.2.4.c | Identify cosmetics and external medications where water is the solvent |
| 9.2.4.d | Identify cosmetics and external medications where alcohol is the solvent |
| 9.2.4.i | Perform an investigation to gather data comparing the rate at which capsules, tablets, enteric coated tablets, and slow-release tablets dissolve |
| 9.2.4.ii | Identify data sources, gather, process, analyse and present information from secondary sources to identify how sub dermal implants release their medication into the body. |
9.2.4.a Identify water and alcohol as commonly used solvents

**Common Solvents**

A solvent is a liquid used to dissolve a solute and form a solution.

Water is a universal solvent. It is capable of dissolving more substances than any other solvent. Alcohol is another frequently used solvent. It is used as a solvent because of its ability to dissolve some substances that will not dissolve in water.

Since water and alcohol readily mix with each other, they are said to be miscible. On the other hand, oil, another frequently used solvent does not mix with water or alcohol. These liquids are said to be immiscible.

**Notes Questions**

1. What is a solvent?
2. Name the universal solvent.
3. Why is alcohol an important solvent?
Solvent properties and their use

Cosmetics are products used to improve a person's appearance. They do this by cleaning, promoting attractiveness, or altering appearance. External medications are used to deliver drugs to the body through the skin.

There are two basic types of solvents

- Fat & oil compounds (Vaseline) and
- Water & water miscible substances (alcohol, glycerin).

Properties of solvents that affect their use in cosmetics and external medications include:
- Ability to transport particular chemicals, (drugs, active ingredients)
- Evaporation (Boiling) temperature
- Toxicity
- Ability to penetrate skin
- Spreadability
- Washability
- Occlusiveness (ability to form an impermeable barrier).

Occlusiveness  Fats and oils are used as solvents in cosmetics and external medications because they occlude the skin. That is, substances like white soft paraffin (Vaseline) cover the skin and form a protective barrier (occlude the skin). A consequence of this is that the moisture in the skin is prevented from escaping. This causes the skin to rehydrate itself – that is absorb water. Also, this rehydration increases absorption of substances by the skin. Therefore drugs will be more readily absorbed when the skin (is occluded) is covered by fat and oil compounds.

Toxicity Water, by itself, is safe to use on the skin. It has a neutral pH and does not affect the skin’s acid mantle. The problem occurs with the substances used with, or dissolved in, the water. For example, just about all water based cosmetics and external medications need to have a preservative added. Unfortunately, these preservatives can be irritating to the skin for a significant number of people. Alcohol is also not toxic to the skin. However, the drying effect of alcohol can cause problems. Alcohol evaporates quite quickly from the skin. This drying effect can cause the population of beneficial micro flora to be significantly reduced. So, water and alcohol are used in cosmetics and external medications because they are non-toxic to the skin.
Evaporation rate and Spreadability  

Alcohol and water are used in cosmetics and external medications because they allow the active ingredient to be evenly spread over the skin. They evaporate leaving a film of the active ingredient behind. Water and alcohol are readily spread over the skin. Oils on the other hand, do not evaporate nor spread easily.

Ability to transport particular chemicals  

The main reason particular solvents are used in cosmetics or external medications is their ability to dissolve and transport chemicals.

- Chemicals that will dissolve in water include:
  - Drugs such as:
    - Antiseptic – e.g. chlorohexidine in savlon
    - Local anaesthetic – e.g. lignocaine
    - Anti-inflammatory – e.g. hydro-cortisone and
  - Substances like the water-soluble vitamins.

- Substances that will dissolve in alcohol include:
  - Essential oils (substances that provide pleasant odour)
  - Drugs such as hydro quinone used for fading sunspots
  - Sunscreens - substances that absorb UV light

- Oils will dissolve or carry in suspension:
  - The essential oils (responsible for flavours; and odours in perfumes)
  - Fat soluble vitamins – vitamins A, D and E

Non-HSC material

Most modern cosmetics and external medications are not simply a solvent with an active ingredient. They are complex mixtures that have bases or vehicles that carry the useful substances. Examples of such bases include fat/oil bases, water miscible bases or water-in-oil emulsions. The final product could be a cream, an ointment or a powder. The useful substances are chemicals that can be absorbed into the skin or lay on top of the skin.

For example, many modern cosmetics and external medications are water–in-oil emulsions. These have a number of advantages. The water phase means the base is easy to spread on the skin (property – spreadable) and is easy to wash off (property – washable). Glycerin can be added to the water phase to soothe the skin, since glycerin is miscible with water. The oil phase provides a barrier that enhances absorption by the skin. It also allows the base to be perfumed via the oil phase. Together the phases can carry a vast variety of drugs and other chemicals. All this means that such a product is acceptable to consumers.
The complex mixtures now used for cosmetics and medications must also have particular properties that allow them to be easily applied to the skin. The table below lists some important properties of products that have fat/oil bases, water miscible bases and w/o emulsions.

Table: Comparison of properties of fat & oil bases and water-miscible ointment bases.

<table>
<thead>
<tr>
<th>Composition / Properties</th>
<th>Fat /Oil bases</th>
<th>Water-in-oil Emulsions</th>
<th>Water miscible bases [Gels]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition</td>
<td>Fats and oils</td>
<td>Eg Hydrous lanolin</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Eg Soft white paraffin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreadability</td>
<td>Difficult</td>
<td>Moderate</td>
<td>Easy</td>
</tr>
<tr>
<td>Washable</td>
<td>Non washable</td>
<td>Poor to wash</td>
<td>Washable</td>
</tr>
<tr>
<td>Ability to hold drugs</td>
<td>Oil soluble drugs only</td>
<td>Solids, oils and aqueous solutions of drugs</td>
<td>Solid and aqueous solutions of drugs</td>
</tr>
<tr>
<td>Ability to release drug</td>
<td>Poor</td>
<td>Fair to good</td>
<td>Good</td>
</tr>
<tr>
<td>Occlusiveness</td>
<td>Good - yes</td>
<td>Sometimes</td>
<td>Poor - no</td>
</tr>
<tr>
<td>Uses</td>
<td>Protectants</td>
<td>Cleansing creams</td>
<td>Drug vehicles</td>
</tr>
</tbody>
</table>

Source: http://www.unc.edu/courses/phar0511/ointments/text/htm

Notes Questions

4. What are cosmetics [2 marks]

5. Two basic types of solvents are fat and oil compounds and water and water-miscible substances. Name an example of each type of solvent. [1 mark]

6. Name FOUR properties of solvents that allow them to be used in cosmetics and external medications. [2 marks]

7. Fats and oils occlude the skin.
   a. What is meant by occlusion in terms of the skin? [1 mark]
   b. What are TWO consequences of the skin being occluded? [2 marks]

8. Explain the relationship between the toxicity of solvents and their use in cosmetics and external medications. [3 marks]
9. Explain the relationship between the evaporation rate and spreadability of solvents and their use in cosmetics and external medications. [3 marks]

10. Name two drugs or other substances that can be dissolved in each of the following:
   a) Fats and oils [1 mark]
   b) Water [1 mark]
   c) Alcohol [1 mark]

11. Many modern cosmetics and external medications are water-in-oil emulsions. These emulsions have a number of properties that make them useful as ointment and cream bases. Describe the emulsions and outline some of the advantages of emulsions. [3 marks]

12. Identify which base (oil or water miscible): [2 marks]
   a) are the easiest to spread?
   b) are the easiest to wash?
   c) Occlude the skin well?
   d) Are used as drug 'vehicles'?

13. A common ointment base is a water-in-oil emulsion.
   a) Name the dispersion medium in a water-in-oil emulsion? [1 mark]
   b) Name the dispersed phase in a water-in-oil emulsion? [1 mark]
   c) Name one example of the oil phase in this type of base? [1 mark]
   d) Outline how can the same emulsion base be varied for different purposes? [2 marks]

14. Alcohol is an important solvent. It has a number of properties. It is:
   - is miscible with water
   - will dissolve sunscreens
   - will dissolve the essential oils
   - is non greasy
   - has a drying effect on the skin (drying is not significant if only used twice a week)
   - irritates the skin (particularly open skin)
   - It also can be used to sterilize the skin and it will kill surface bacteria.

   For TWO properties, identify a product in which alcohol is used as a solvent. [1 mark]
9.2.4.c Identify cosmetics and external medications where water is the solvent

**Water as a solvent**

External medications that will dissolve in water include:
- Antiseptic – eg chlorohexidene in savlon
- Local anaesthetic – eg lignocane
- Anti-inflammatory – eg hydro-cortisone

Cosmetics that contain water as the solvent include
- moisturising cream
- shampoos
- foundation cream

9.2.4.d Identify cosmetics and external medications where alcohol is the solvent

**Alcohol as a solvent**

Alcohol is another important solvent. It has a number of specific properties. Alcohol
- is miscible with water
- is a good solvent of sunscreens - substances that absorb UV light
- will dissolve the essential oils

Products where alcohol is the solvent include
- nail polish
- deodorants
- suntan lotions
- shaving cream
- hair spray

The essential oils are volatile liquids. They evaporate quickly especially when heated. They are mostly insoluble in water but freely soluble in alcohol, ether, and vegetable and mineral oils. They are usually not oily to the touch. They may be grouped into five classes, according to their chemical structure: alcohols, esters, aldehydes, ketones, and lactones and oxides.

These oils are responsible for many flavours of food and other products. The taste of food flavourings such as lemon, mint and vanilla extracts results from the volatile oils. Volatile oils like lemon are used to give scent to soaps and other cleaning products.
Introduction to Activity 4 - 1

Most drugs are given orally in solid forms (tablets, capsules). This is mainly for convenience, economy, stability and patient acceptance. If drugs are taken in a solid form they must break up before the active ingredient is available for absorption. This break up converts drug molecules from the solid state to suspension in a liquid so that they can be dissolved. Therefore, a tablet needs to break up into granules, then into fine particles and then it eventually dissolves. Various substances (lubricants, surfactants, binders, dispersants) are added to the tablet or capsule to assist with break-up, dissolving and absorption.

Tablet

Tablets are combinations of drug, binders and other substances compressed into hard masses that can disintegrate in water. A tablet must first disintegrate and then dissolve so that it is in soluble form. It is then absorbed, usually down a concentration gradient by diffusion. Tablets like capsules can be enteric-coated or can be prepared for slow release.

Tablet Slow Release

The formulation of a slow release tablet allows it to dissolve slowly over time. The medication is released gradually as the medication travels through the Gastro Intestinal Tract.

Tablet Enteric-coated

The tablet is covered in a coating that doesn’t dissolve in the stomach: That is the tablet bypasses the stomach. The tablet then dissolves in the small intestine as it has a different pH. Once in the small intestine the active medication may be released.

Capsule

Capsules can be divided into two main groups. In both kinds the gelatin coating must first dissolve. This occurs quickly in the acidic environment of the stomach.

- Type 1. Powder inside a gelatin cap. The gelatin dissolves then the powder must dissolve and mix with the gastric juices to form a solution and it is then absorbed.
- Type 2. Liquid inside a gelatin cap. The gelatin dissolves and the liquid is ready to be absorbed straight away.

Capsules may be "enteric coated", ie. made resistant to acid-disintegration in the stomach, or "delayed-action", which permit more sustained release of drug.

Notes Questions

15. What must happen to a tablet before it is absorbed?
16. What is the advantage of an enteric coated tablet?
Reviewing Risk assessment

The Occupational Health and Safety Regulation requires an assessment to be made of risks to health which might arise from work which involves exposure to hazardous substances.

The process, known as risk assessment, requires users of chemicals to identify the hazard, and then assess and control the risks from hazardous substances.

For science investigations it is necessary to identify all the substances used. Then it is necessary to determine if they are hazardous – this can be done using the label and the MSDS (Material Safety Data Sheet). Information about the level of hazard, routes of exposure, recommended control measures and other actions to prevent or minimise risks can be found on the MSDS sheets.

The risk must then be evaluated. The risk may generally be described as ‘not significant’ or ‘significant’. If there is not a significant risk to health, then the assessment is complete. If the risk is significant further actions should be taken. These measures may include:

- Substitution with a less hazardous substance
- Engineering methods (eg local exhaust ventilation systems)
- Personal Protective Equipment

Personal Protective Equipment

Selection of personal protective equipment depends on the degree of risk.

- Eye protection – In any area where there is a possibility of eye damage from flying objects (near lathes, chemical splashes) appropriate eye protection must be worn. This could be in the form of safety glasses, goggles, a face shield or a full-face respirator. Ordinary prescription spectacles do not provide sufficient protection.

- Gloves – Gloves should be worn during cleaning operations and dealing with chemical spills to protect the skin. Gloves should also be used when decanting solutions and some biological situations.

- Hair – Loose hair poses a significant hazard in laboratories. It is essential that students and staff securely fix and confine hair when working in laboratories where naked flames are used (tie back or use hair net).

- Respiratory protection – Experiments using volatile toxic chemicals should be carried out in a fume cupboard.

- Footwear – It is mandatory that students carrying out practical activities using chemicals or equipment in schools wear enclosed leather footwear. Sandals, open footwear or high healed shoes must not be worn in workshop areas or laboratories.
What to do

Summarize the information on personal protective equipment using the table below

<table>
<thead>
<tr>
<th>Protective equipment</th>
<th>Associated risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye protection in the form of safety glasses, goggles or a full face respirator</td>
<td>Possibility of eye damage from flying objects such as chemical splashes</td>
</tr>
</tbody>
</table>

Questions

Complete the following questions for activity 4-1

1. Read the MSDS sheet for Hydrochloric Acid

   The hazard rating of hydrochloric acid is affected by the molarity of the acid. This impacts on who may use the hydrochloric acid.
   - 10M - Conc HCl (RED) Only by approved teachers for demonstrations
   - 4 – 9M (ORANGE) Can be used by Senior students
   - 0.2M – 4 M (GREEN) 7 - 12 students
   - < 0.2 M – Not hazardous (BLUE) Can be safely used with students K - 12

   a. Identify the Chemwatch Hazard Rating for toxicity and body contact
   b. Describe the health effects associated with skin contact.
   c. Explain why the vapour should not be inhaled
   d. What first aid is needed if hydrochloric acid comes into contact with the eye.
   e. Outline what should happen if some acid is spilled
   f. How should hydrochloric acid be disposed of?

2. Read the MSDS sheet for Sodium Hydroxide. Write a report outlining the safety issues related to the use of Sodium Hydroxide.

3. In activity 4-1 name the chemical that could be used to replace hydrochloric acid.

4. In activity 4-1 is there any need for using engineering methods to reduce risk (eg local exhaust ventilation systems)?

5. Outline safety issues related to activity 4-1
9.2.4.i Perform an investigation to gather data comparing the rate at which capsules, tablets, enteric coated tablets, and slow-release tablets dissolve in acid, neutral and alkali solutions.

**Activity 4–1 Rate of dissolving**

**Aim** To compare the rate at which capsules, tablets, enteric-coated tablets and slow-release tablets dissolve in acid, neutral and alkali solutions.

**Method**

1. Pour 50mL of distilled water to each of four separate beakers or plastic cups.
2. Note the time (time = 0)
3. Then, at the same time add:
   - An aspirin capsule to the first beaker.
   - An aspirin tablet (eg Bayer aspirin tablets) to the second beaker.
   - An enteric coated tablet (eg Cartia (dientric coated low dose aspirin)) to the third.
   - A slow release tablet (eg Fefol (delay release iron & folate capsules)) to the fourth.
4. Observe to see if the tablet dissolves and if it does measure how long it takes to dissolve. Some of the tablets will take a long time to dissolve and may need to be left overnight. Record any changes observed.
5. Repeat the above four steps by replacing water with:
   - 1M hydrochloric acid (or vinegar), and then
   - 1M sodium hydroxide (or 2.5 g of baking soda in 50 mL of water)
6. The whole investigation should be completed twice (or by separate groups).
   - First use liquids at room temperature (~25°C) and then
   - Use liquids at body temperature (~37°C).
7. Record individual and class results in a table

**Precaution** Care should be taken with the distribution of these drugs. Each group must use only the minimum number of tablets.

**Results**

- Data should be recorded in a table
- Both individual and group data should be recorded in the same table.

**Conclusion**

Write a statement that is consistent with the data collected.
<table>
<thead>
<tr>
<th>Marking Criteria</th>
<th>Mark range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform planned practical (12.1)</td>
<td></td>
</tr>
<tr>
<td>[3 marks]</td>
<td></td>
</tr>
<tr>
<td>• Carry out planned procedure safely</td>
<td>At all times</td>
</tr>
<tr>
<td>• Use safe working practices</td>
<td>Mostly</td>
</tr>
<tr>
<td></td>
<td>Occasionally</td>
</tr>
<tr>
<td>Data collection (12.2)</td>
<td></td>
</tr>
<tr>
<td>[5 marks]</td>
<td></td>
</tr>
<tr>
<td>• Record changes observed</td>
<td>All criteria</td>
</tr>
<tr>
<td>• Accuracy of measurements</td>
<td>Most criteria</td>
</tr>
<tr>
<td>• All data collected (main criteria)</td>
<td>Few criteria</td>
</tr>
<tr>
<td>Results table (13.1)</td>
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</tr>
<tr>
<td>[5 marks]</td>
<td></td>
</tr>
<tr>
<td>• Ruled</td>
<td>All criteria</td>
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<tr>
<td>• Column headings</td>
<td>Most criteria</td>
</tr>
<tr>
<td>• Units &amp; Column headings</td>
<td>Few criteria</td>
</tr>
<tr>
<td>• Accurate data recorded</td>
<td></td>
</tr>
<tr>
<td>Conclusion (14.1)</td>
<td></td>
</tr>
<tr>
<td>[2 marks]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Totally consistent</td>
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<tr>
<td></td>
<td>Logical</td>
</tr>
</tbody>
</table>

**Discussion questions**

1. In this experiment the independent variable is the type of tablet. What is the dependent variable?  [1 mark]

2. In order to make valid comparisons certain variables must be controlled.
   a. Identify the controlled variables in this investigation.  [2 marks]
   b. Identify any variables that are not controlled in this investigation.  [2 marks]

3. Three groups are being compared in this experimental investigation.
   a. Name the three groups being compared.  [1 mark]
   b. Identify the Control Group.  [1 mark]

4. Outline how the dependent variable is measured in this investigation.  [2 marks]

5. a. What type of activity is this investigation?  [1 mark]
   b. What other types of scientific investigations are there?  [2 marks]

6. What features of the method makes this investigation reliable?  [2 marks]

7. In this investigation there was “destructive testing of materials” rather than “non-destructive testing of materials”.  [4 marks]
   a. Outline what is meant by these two terms (ie “destructive ..”, “non-destructive ..”)  [4 marks]
   b. Explain why it is not an important issue in this investigation.
8. **Assess** the **validity** of the **conclusion** in this investigation [7 marks]

This question is unstructured and requires an extended answer

- In order to answer such a question, you must provide some structure.
  - **STEP 1** Identify (& highlight) the important words in the question
  - **STEP 2** Recall definitions of these important words (if necessary)
    - Assess – Make a judgement of value, quality, outcomes, results or size
    - Validity – Right method
    - Conclusion – A statement that answers or responds to the aim or hypothesis.
  - **STEP 3** Develop a structure that reflects the depth required (Verb & marks)
    - Clearly make a judgement about the quality of the conclusion.
    - Outline purpose of investigation
    - For this investigation outline the conclusion reached
    - Describe what constitutes a valid conclusion
      - For a valid investigation the only independent variable should result in changes in the dependent variable. All other variables should be controlled.
    - Discuss aspects of validity (right method) and how these aspects affect the quality of the conclusion. Use VGMANS as an aid
      - Outline of variables that were controlled and how this related to validity
      - Outline variables that could not be controlled and how this relates to validity
      - Outline how this investigation was reliable. Could reliability be improved? How could this be related to validity?

### Marking Criteria

<table>
<thead>
<tr>
<th>Marking Criteria</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A judgement is made about the quality of the conclusion that is supported by a discussion of at least four factors that could affect validity, specific to the investigation on the rate at which tablets etc will dissolve.</td>
<td>7</td>
</tr>
<tr>
<td>A judgement is made about the quality of the conclusion that is supported by a discussion of at two or three factors that could affect validity.</td>
<td>6</td>
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<tr>
<td>Discussion of two or three factors that could affect validity, specific to the investigation on the rate at which tablets etc will dissolve.</td>
<td>5</td>
</tr>
<tr>
<td>Description of two or three factors that could affect validity, specific to the investigation on the rate at which tablets etc will dissolve.</td>
<td>4</td>
</tr>
<tr>
<td>Description of factors that affect validity</td>
<td>3</td>
</tr>
<tr>
<td>Outline two factors that affect validity</td>
<td>2</td>
</tr>
<tr>
<td>Name one factor that affects validity</td>
<td>1</td>
</tr>
</tbody>
</table>
Delivering medication to the body

The traditional form of taking drugs has been to take a capsule or tablet. When the tablet is taken, drug concentration rises, reaches a maximum, and then falls. A second tablet causes the same rise, peak and fall in the concentration of medicine in the bloodstream. This rising and falling is shown in the graph below. The problem with this method is that the preferred concentration cannot be maintained and the peaks may occur at toxic levels.

Sustained, or time release, systems are methods of drug delivery that are becoming more common. Three important examples of these are: micro encapsulation, dermal patches and sub-dermal implants.

Advantages of sustained release systems

1. Increased effectiveness
   - Because the drug is delivered more efficiently, smaller doses are needed.
   - This causes less potential damage to the body.
2. More patient friendly
   Sustained release systems take much of the responsibility associated with drug treatments out of the patients' hands. Because of this, they improve consumer convenience, and consequently, consumer compliance
3. Rapid identification of medication in emergency
4. Avoids gastrointestinal absorption (pH effects, enzymatic activity, drug interactions). Some drugs are destroyed in the stomach and intestines before they can be absorbed.
5. Avoids first-pass effect (drug deactivation by digestive and liver enzymes). Blood that leaves the stomach and intestine must first pass the liver before it is carried to other parts of the body. The function of the liver is to remove foreign chemicals from the blood.
**Sub-dermal Implants**

Implantable systems are designed to deliver drugs directly into the bloodstream at a controlled rate. A wide variety of chemicals have been used in an attempt to promote the penetration of drugs. Chemicals that promote absorption include surfactants and solvents such as alcohol.

**Pumps** Implantable pumps for drug delivery have been developed for treatment of several ailments, such as diabetes and cancer. These pumps reduce the need for repeated insulin or chemotherapy.

- One advantage of a pump is the elimination of infection that results from repeated needle injections at the same site.
- Disadvantages include the size of the pump, restricted access to the pump, potential of drug leakage from the reservoir, and possible infection due to implant surgery.

Implantable pumps deliver a set amount of drug each time an electric impulse drives the pump. In some examples, the pump, electronics, and power source are housed in a titanium shell. The drug reservoirs are silicone rubber pouches and they can be refilled. A two-way communication system allows the person to control delivery rates and check on pump operation.

**Polymer Implants** A polymeric implant consists of the drug embedded in a polymer matrix. It is surgically planted into the body (in the affected area). The drug is then released directly into the affected site when

⇒ The drug diffuses through the polymer or

⇒ The polymer gradually “erodes away”.

For example, Norplant is an implantable birth control system. The implant uses a non-degradable polymer, called Silastic, to contain the contraceptive, levonorgestrel. Since the Silastic does not break down, the drug is released by diffusion through the polymer. There are six Silastic capsules each about 34mm long. They are inserted below the skin in the upper arm. The Silastic gradually releases the drug over a period of 5 years.
Research

✓ Use the Internet to find one source of information on how sub dermal implants release their medication into the body.

✓ Then answer the questions below

Questions

1. Identify what is information are you trying to gather?

2. What is the correct method to identify an Internet source in a bibliography?

3. Identify two Internet sources that provide the required information.

4. Compare the quality of information from each source.

5. Compare the information from the two sources you have found to the information in the source mentioned below