Environmental Science and Technology—558-404

Secondary Cycle Two, Year Two

June 2010

The Green Grocer

Theory Examination

Student Question Booklet

Commission scolaire English-Montréal
English Montreal School Board

Instructions

1. This examination consists of 5 tasks. This booklet contains the tasks and the background information needed to answer the questions for each task.

2. Read and refer to, as needed, the evaluation criteria (page 2) and the evaluation rubrics (pages 3 and 4).

3. Answer all questions in the Answer Booklet. Each question is evaluated on a scale of 1 - 5 according to the evaluation rubric.

4. You are permitted to use a calculator *without* a graphic display.

5. You may refer to the lists of formulas, quantities, polyatomic ions and the periodic table included in the Appendix to this booklet. The use of any other reference material is strictly forbidden.

Note: Figures are not necessarily drawn to scale.

Context

An entrepreneur is interested in opening a small neighbourhood grocery store. In addition to being able to make a living on the profits of the store, he is committed to providing a service that is environmentally friendly and a service that endorses healthy living.

He has several choices to make for his store. Your task is to analyze some of these choices and to provide the grocery store owner with explanations and recommendations from scientific, environmental, human and economic perspectives.

Task 1: Fuel for Thought

The owner is looking for inexpensive, environmentally friendly ways to heat the store. The heating system in the store depends upon the combustion of a fuel. His budget does not allow him to change the heating system, but he wants to choose the fuel with the smallest impact on the environment. He has narrowed his choice to two options.

Your task is to:

a) Determine the amount of carbon dioxide produced by each fuel per month.

b) Recommend which fuel the grocer should use.
Justify your choice based upon the carbon dioxide emissions for the combustion of the fuels, as well as the environmental impact of the life cycle of the fuel.

Choice 1: Natural Gas

Description:

- Natural gas is considered to be the "cleanest" burning of fossil fuels
- It is composed mostly of methane, CH_4. For this problem, you will assume that natural gas is 100% methane.

Balanced Chemical Equation For Combustion of the Fuel:

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

Mass of fuel required per month to heat store: 141 kg

Choice 2: Biodiesel

Description:

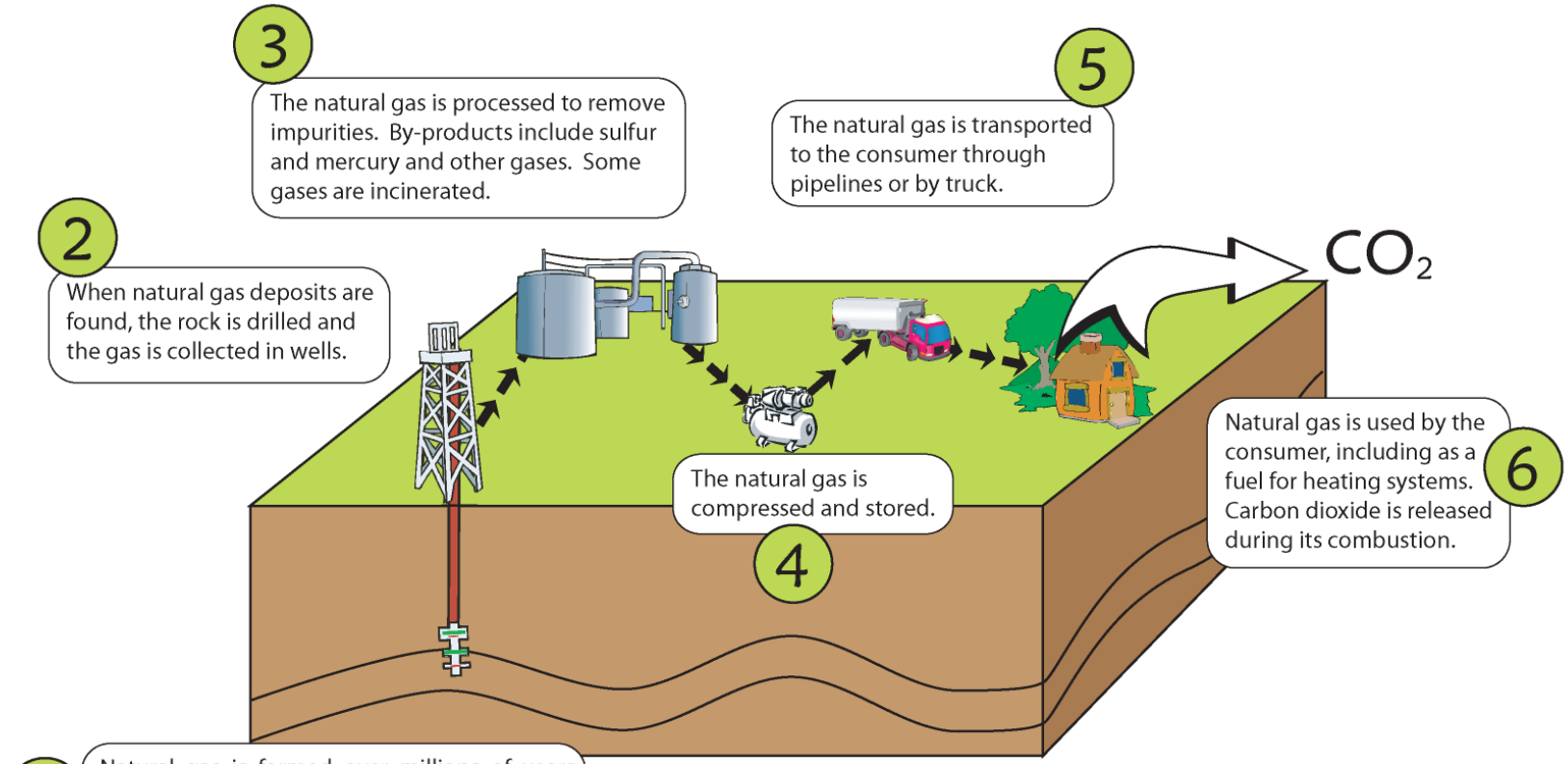
- Furnaces can be fitted to burn biodiesel, which is a vegetable oil fuel.
- For this problem, you will assume that B-100 is used, a 100% vegetable oil fuel.

Balanced Chemical Reaction for the Combustion of the Fuel:

$$C_{19}H_{36}O_2 + 27\ O_2 \rightarrow 19\ CO_2 + 18\ H_2O$$

Mass of fuel required per month to meet energy demands: 186 kg

Life Cycle of Natural Gas



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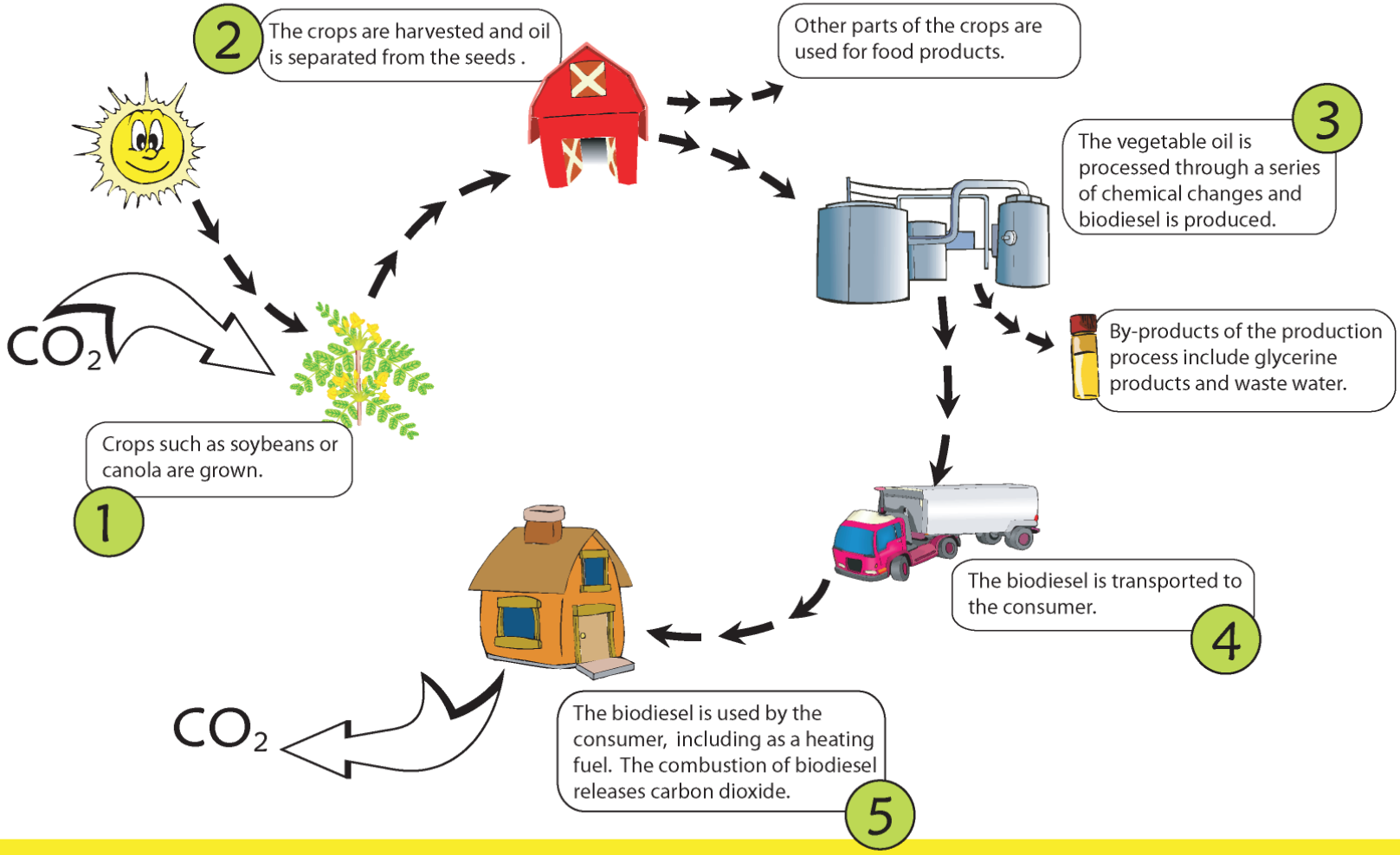
Life Cycle of Biodiesel



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Task 2: Something Fishy

The grocer wants to promote the consumption of salmon because he knows about the health benefits of this fish.

Salmon is also known to contain mercury (Hg), which is dangerous to human health. As a result, Health Canada has released recommendations on the maximum amount of salmon that should be consumed per month. These recommendations are different for farmed salmon and for wild salmon.

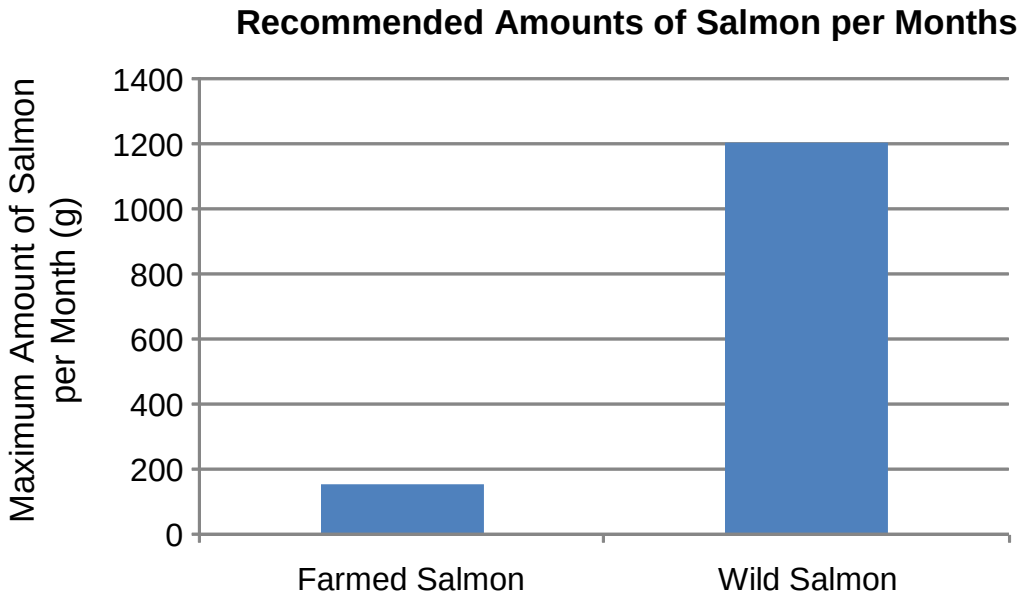
Your task is to:

- **Analyze the Health Canada Recommendations and Background information on mercury, farmed salmon and wild salmon.**

- **Explain why the recommendations for the maximum amount of salmon consumed per month are different for farmed salmon and wild salmon. Refer to established scientific principles in your explanation.**

Health Canada Advisory

The maximum number of recommended meals per month for farmed and wild salmon is provided below.



Mercury Contamination in the Environment

Mercury is a highly toxic element that is found both naturally and as an industrial pollutant in the environment.

- Mercury falls from the air and can accumulate in streams and oceans where it is converted into methylmercury (CH_3Hg) by some types of bacteria in the water.
- These methylmercury (CH_3Hg)-containing bacteria may be consumed by the next higher level in the food chain, or the bacteria may excrete the methylmercury (CH_3Hg) into the water where it can quickly stick to plankton.
- Fish absorb the methylmercury (CH_3Hg) as they feed on organisms in these waters.

Farmed Salmon

Farmed salmon are bred and raised in pens in the ocean. They are fed fish meal (ground-up fish) and fish oil. Farmed salmon are selectively bred to be large and are generally much fattier than wild salmon.

Food Chain for Farmed Salmon

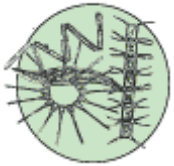
Fish Meal

Farmed Salmon

Medium fish are ground into fish meal

Medium Fish

Small Fish



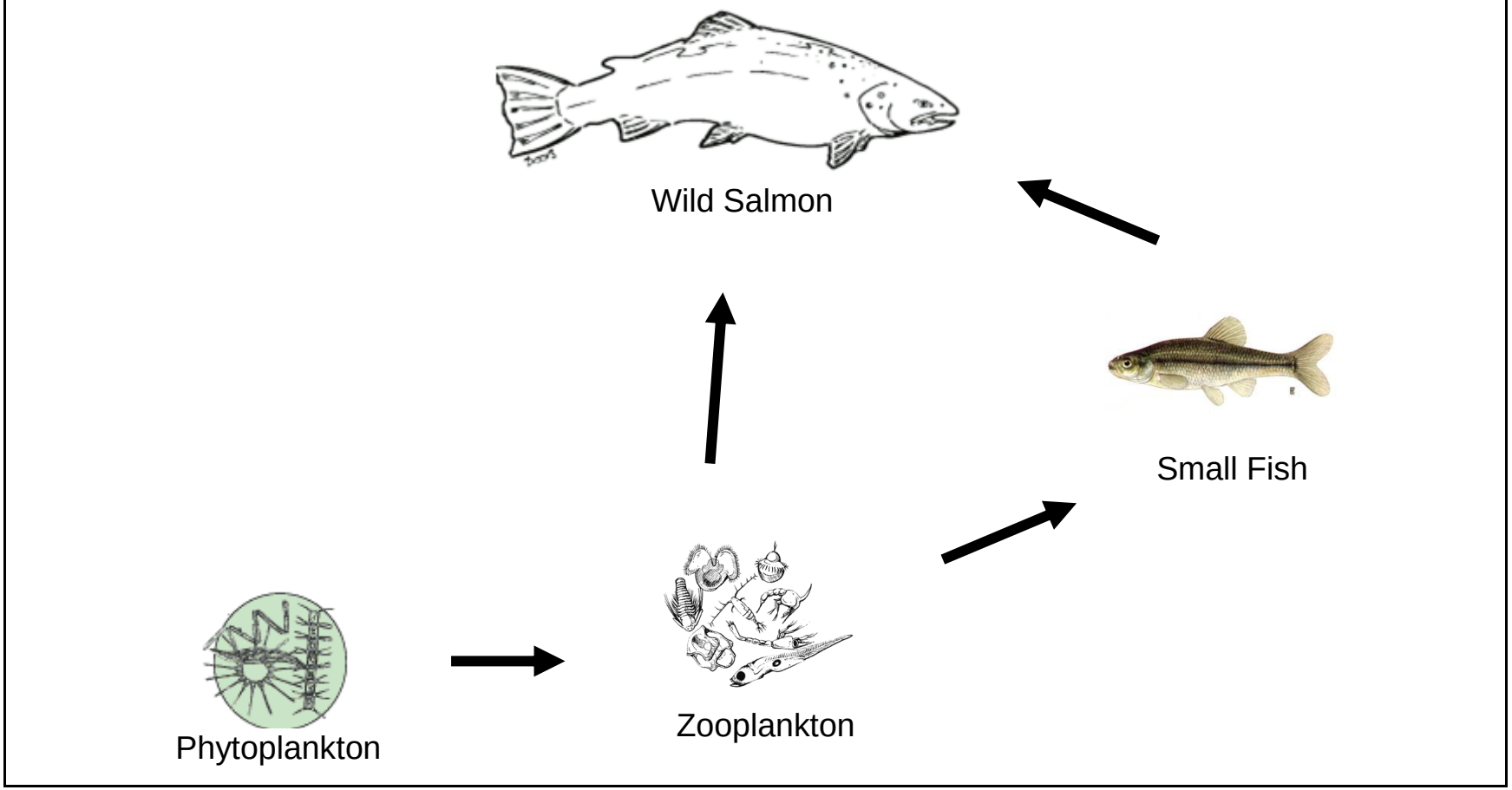
Phytoplankton

Zooplankton

Wild Salmon

Wild Salmon are fished commercially and sold to the consumer. They feed on zooplankton and small fish.

Food Chain for Wild Salmon



Task 3: A Better Bulb

The grocer is trying to decide between Light Emitting Diodes (LEDs) and Compact Fluorescent Lamps (CFLs) for the ceiling lights in the store's office.

The grocer would like to reduce the costs and the environmental impact of lighting his store.

An electrician has proposed two options to the grocer: a series circuit with LEDs or a parallel circuit with CFLs. These circuits are shown on the following pages.

Your task is to analyze these choices and to:

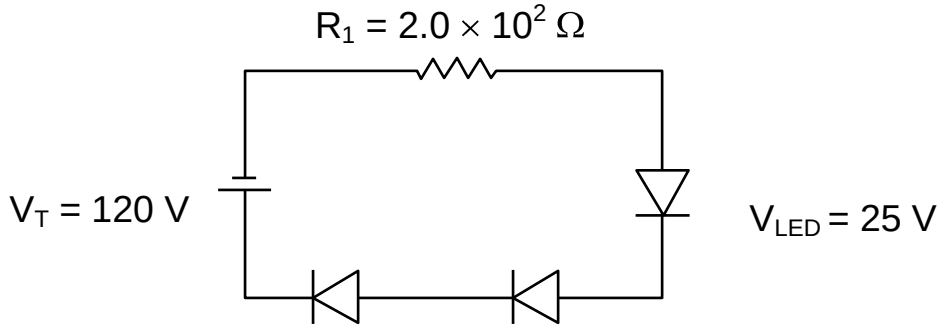
a) Determine the amount of electrical energy that would be consumed by each lighting option in a day. Assume that the lights are used for 5 hours in a day.

b) Recommend which lighting option the grocer should choose and justify your choice. Include arguments from scientific, environmental and economic perspectives in your justification.

Electrical Energy Facts
• Electrical energy can be expressed in kW•h • 1 kW•h = 3 600 000 Joules • Electrical energy costs 7 ¢/kW•h

Lighting Option 1:

Three identical LEDs, each with a voltage of 25 volts, are connected in series to a 120 V circuit. The electrician added a 2.0×10^2 ohm resistor in series to limit the current supplied to the LEDs.

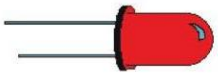


Each LED in this circuit costs $57.00 and has a lifespan of approximately 30 000 hours.

Light Emitting Diodes (LEDs)

General Description

Light emitting diodes are gaining popularity as a choice for lighting in homes and offices. The LED light recommended by the electrician consists of several small LEDS cased in an aluminum housing.

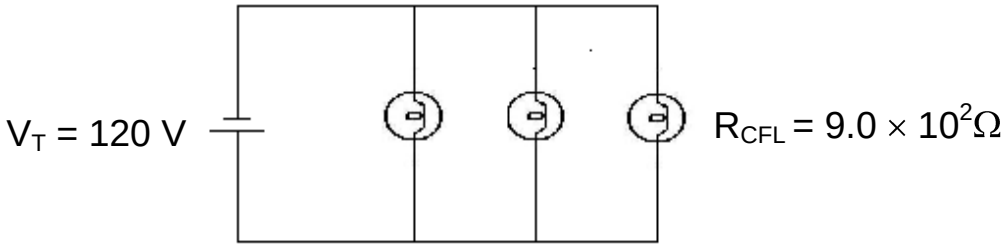
 Single LED	 Ceiling light consisting of several LEDs encased in aluminum housing

Characteristics of LED lights

- LEDs convert electricity into light with relatively little excess heat released.
- LEDs are made of very thin layers of semiconductor materials.
- Each single LED is encased in a durable plastic housing.
- LEDs can be disposed of in regular garbage.

Lighting Option 2

Three identical CFLs, each with a resistance of 9.0×10^2 ohms, are connected in parallel to a 120 V circuit.



Each CFL in this circuit costs $17.00 and has a lifespan of 6 000 hours.

Compact Fluorescent Lamp (CFLs)

General Description

Compact Fluorescent Lamps are widely used as a more energy efficient alternative to the traditional incandescent light bulb.

Characteristics of CFLs

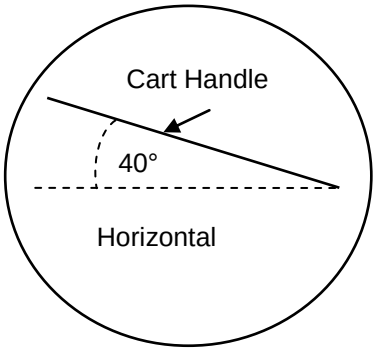
- A CFL is a smaller version of the fluorescent lamps used in schools and offices
- A CFL consists of a sealed glass tube. The tube is coated with phosphor powder and contains an inert gas.
- CFLs contain a small amount of mercury so they must be disposed of as hazardous waste

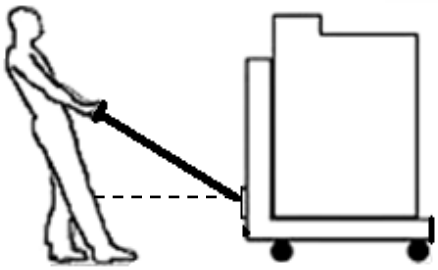
Task 4: Enforcing the Rules

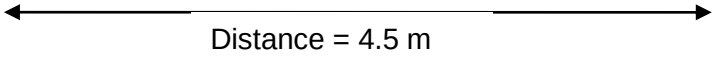
One of the tasks in the store is to receive the delivery of food. An employee will help unload the food delivery onto a cart and then use the cart to pull the goods to the shelves in the storeroom.

The grocer must respect the guidelines from the Workplace Health and Safety Board on the prevention of injuries at work. These guidelines state that his employees should not be required to apply a force of more than 85 Newtons when pulling the cart.

The grocer has collected some data on the carts and how they are used in order to determine if the guidelines are being respected.







- The handle is at an angle of 40° to the horizontal
- The cart is pulled for 4.5 m
- The effective force is 40 N

Assume that the floor is frictionless.

a) Determine whether or not the use of the cart as described above respects the guidelines of a maximum applied force of 85 N.

b) Calculate the how much work is done when the cart is used as described above.

Task 5: The Grocer's Garden

The store has a small yard with a garden plot. Two different types of tomato plants have been planted in the garden.

The grocer started to collect information about the plants, but never organized it.

Your task is to analyze and interpret the information provided.

a) Read "Genetics Information" and complete the table in your answer booklet.

Genetics Information
Trait 1: Shape The allele for a round shape (R) is dominant over the allele for oval shape (*r*) **Trait 2: Resistance to disease** The allele for resistance to the tomato blight disease (D) is dominant over the allele for susceptibility to the disease (*d*). *Note: The genetics of the tomato plant has been simplified for this problem*

b) List the possible genotypes and phenotypes of the offspring created from a cross between plant 1 and plant 2.

c) Read the article "Growing Better Tomatoes-Calcium Needed".

i. Complete the table *Methods for Adding Calcium to the Garden* in the Answer Booklet

ii. Prepare a set of clear instructions for preparing enough 0.040 mole/L calcium nitrate solution to fill a standard 7.6 L capacity garden sprayer.

Growing Better Tomatoes-Calcium Needed!

If you are a gardener trying to produce the best tomatoes possible, you have probably come across many different problems along the way. Many of these problems can be traced to calcium deficiencies.

You can provide calcium to your plants by making sure that there is enough calcium in the soil. One method of adding calcium is to mix agricultural lime (calcium carbonate) into the soil before you plant your tomatoes. Alternatively, you can mix crushed egg shells into the soil. This is an exceptional way to add calcium and nutrients to the soil. An eggshell contains about 95% calcium carbonate. The remaining 5% is comprised of calcium phosphate, magnesium carbonate, and proteins.

However, if you suspect a calcium deficiency once your plants have started to grow, spraying a fertilizer solution containing calcium on the plants will be a more effective method. You can choose either a calcium chloride or a calcium nitrate solution. For best results, research has shown that the concentration of the calcium nitrate solution should be as close to 0.040 moles/L as possible. Calcium nitrate can be purchased in granular form from agricultural supply companies.

Appendices

Formula Sheet

Common Quantities and Polyatomic Ions

Periodic Table

FORMULAS

$C = \frac{m}{v}$	C: concentration m: mass V: volume		$W = \Delta E$	W: work ΔE: variation in energy	
$V = RI$	V: potential difference R: resistance I: electric current intensity		$W = F\Delta d$	W: work F: force Δd: distance travelled	
$R_{eq} = R_1 + R_2 + ...$	R_{eq}: equivalent resistance		$F_g = mg$	F_g: gravitational force m: mass g: gravitational field intensity	
$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$	R_{eq}: equivalent resistance		$E_p = mgh$	E_p: gravitational potential energy m: mass g: gravitational field intensity h: height	
$E = P\Delta t$	E: energy consumed P: power t: time		$E_k = \frac{1}{2}mv^2$	E_k: kinetic energy m: mass v: velocity	
$P = VI$	P: power V: potential difference I: electric current intensity		$Q = mc\Delta T$	Q: quantity of heat m: mass c: specific heat capacity ΔT: change in temperature	
$F_e = \frac{kq_1q_2}{r^2}$	F_e: electrical force k: Coulomb's constant q: charge of particle r: distance between two particles				

QUANTITIES		
NAME	**SYMBOL**	**VALUE**
Coulomb's constant	k	$9 \times 10^9 \ \frac{Nm^2}{C^2}$
Gravitational field intensity	g	9.8 N/kg

Examples of Common Polyatomic Ions

NAME	CHEMICAL FORMULA
Acetate	CH_3COO^-
Ammonium	NH_4^+
Bicarbonate	HCO_3^-
Carbonate	CO_3^{2-}
Chlorate	ClO_3^-
Chromate	CrO_4^{2-}
Hydroxide	OH^-
Nitrate	NO_3^-
Phosphate	PO_4^{3-}
Sulphate	SO_4^{2-}

PERIODIC TABLE OF THE ELEMENTS