1a) ISWM is a comprehensive waste prevention, recycling, composting + disposal program that selects and combine the most appropriate waste management activities based on local needs and conditions to protect human health and the environment.

4Rs = Reduce, Reuse, Recycle, Recovery

1b)

HCS	SCS
Waste collection vehicles pick up container filled with waste to bring to disposal site and return empty container. Adv: Good for places that generate high volume of waste. Eliminates spillage. Large containers can be carried away Disadv: Potential for low utilisation rate	All waste is unloaded into bigger trucks equipped with internal compaction. Adv: Higher utilisation rate per vehicle can be achieved Disadv: Not flexible method as bulky items cannot be collected. Capacity of vehicles may not be able to cater to large generation of waste.

1c) Method: Incineration

Advantages: Reduce volume, destroy contaminants, recovery of waste energy, stabilisation of waste (make waste non-reactive)

Disadvantages: High cost, public disapproval due to harmful products such as NO_x , SO_x , HCl. Non-combustible materials not treated.

1d) Tip: Products produced will mostly be as the name of stage suggests

Stage 1 Hydrolysis: Breakdown of complex biopolymers to products like sugar, amino acids, peptides

Stage 2 Acidogenesis: Volatile Fatty Acids (VFAs)

Stage 3 Acetogenesis: VFAs broken down by acetogens to produce H_2 + CO_2 + Acetate

Stage 4 Methanogenesis: Acetate breaks down into CO_2 and CH_4 (Methane gas is MAIN PRODUCT)

2a) Corrosive, Toxic, Ignitable, Reactive, Eco-toxicity (CTIRE)

2b) Hazard Identification → Dose-response assessment → Exposure assessment → Risk characterisation

2c) Pollutant Standard Index (PSI) measures 6 air pollutants of

24-hr $PM_{2.5}$ 24-hr PM_{10} 24-hr SO_2 8-hr CO 8-hr O_3 1-hr NO_2

PSI readings provide information on the level of each of these pollutants in the air

2d) Basel Convention is the global approach to control transboundary movement of hazardous waste.

Prevention and penalisation achieved through national and domestic legislation. Movement considered illegal without notification/constant consent of parties involved or if consent was faked.

3a) In 1 hour

Heat input = (82%+6%) × 1000kg/h × 17,000kJ/kg = 1.496×10^7 kJ

Heat loss due to radiation = $0.04 \times 1.496 \times 10^7$ kJ/h = 5.984×10^5 kJ

Heat used for evaporation of water = 12% × 1000kg/h × 2575kJ/kg = 3.09×10^5 kJ

Actual heat produced by combustion = $92\% \times 1.496 \times 10^7$ kJ/h = 1.37632×10^7 kJ

Heat left in ash = 0.04×1000kg/h × 0.837 kJ/kg/˚C × 830˚C = 2.77884×10^6 kJ

Heat used to heat up air = $(1.37632 \times 10^7$ kJ) – $(3.09 \times 10^5$ kJ) – $(5.984 \times 10^5$ kJ) – $(2.77884 \times 10^6$ kJ)

= 1.0077×10^7 kJ

Temperature of stack gases = 1.0077×10^7 kJ ÷ 9000kg ÷ 1 kJ/kg/˚C = 1119.66 ˚C

3b(i) In 1 week, waste generated by family = 2kg/per person/day × 4 people × 7 days = 56kg

Capacity required = 56kg ÷ 200kg/m^3 = 0.28m^3 = 280L

No. of 40L garbage cans = 280L ÷ 40L = 7

3b(ii) No. of blocks = 56kg ÷ 20kg = 2.8 blocks

Space taken up by blocks = 56kg ÷ 1400kg/m^3 = 0.04m^3 = 40L

No. of 40L garbage cans = 40L ÷ 40L = 1

3c(i)

$$Calorific\ value = \frac{1{,}144{,}820\ kJ}{100\ kg}$$

$$= 114{,}48.2\ kJ/kg$$

3c(ii)

$$\text{Total energy after segregation} = 1{,}144{,}820 - (0.5 \times 569{,}500) - (0.8 \times 97680)$$

$$= 781{,}926\ \text{kJ/kg}$$

4a)

$$(TLV - TWA)_{mix} = \sum_{i=1}^{n} \frac{c_i}{TLV - TWA_i}$$

$$= \frac{0.1}{0.5} + \frac{10}{50} + \frac{50}{200}$$

$$= 0.65$$

Value is <1, therefore will not have adverse health effects.

4b(i) Dioxins refer to a family of around 200 chlorinated organic compounds, few of which are highly toxic. During incineration, dioxins formation occur if temperatures fall below 870˚C.

4b(ii) Note: W in g/min, $1m^3$ = 1000L

Dioxin	Furan
$DRE = \frac{W_{in} - W_{out}}{W_{in}} X\ 100\%$	$DRE = \frac{W_{in} - W_{out}}{W_{in}} X\ 100\%$
$W_{in} = 1.7L/\min \times \frac{2.05g}{mL}$ $W_{in} = 3485g/min$	$W_{in} = 1.3L/\min \times \frac{0.95g}{mL}$ $W_{in} = 1235g/min$
$W_{out} = \frac{1000m^3}{min} \times 300\mu g/m^3$ $W_{out} = 0.3g/min$	$W_{out} = \frac{1000m^3}{min} \times 300\mu g/m^3$ $W_{out} = 0.3g/min$
$DRE = \frac{3485 - 0.3}{3485} X\ 100\%$	$DRE = \frac{1235 - 0.3}{1235} X\ 100\%$
$DRE = 99.99\%$	$DRE = 99.9757\%$
Meets regulations	Do not meet regulations

All the best 😛

Tay Yu Ting