

Supporting Reasoning Sheet

1. Hyperthermia in Cancer Therapy

- Heat (40-45°C) → cancer cells more sensitive to radiotherapy / chemotherapy (radiosensitization, chemosensitization)
- Cancer cells have poor heat tolerance compared to normal cells.
- Heat transfer in body is difficult to control because of different thermal conductivity and blood perfusion.
- Whole-body hyperthermia → risk of systemic stress, affect major organs (liver, heart, kidney)

Principles : Heat transfer (conduction, convection, perfusion)
Thermal biology, Radiosensitization
Chemosensitization

2. Process Analytical Technology (PAT)

- Real-time measurement & analysis of process parameters and product quality.
- Critical Quality Attributes (CQAs) for powders / granules → particle size, uniformity, moisture, etc.
- Multivariate Statistical Methods (MSMs) → analyze many variables at once.
- Data fusion → combine data from multiple sensors → better performance and robustness of models.
- Continuous processing → integrate many unit operations → improve productivity, quality, safety.

Principles : Analytical chemistry, Chemometrics, Process control, QbD (quality by design)

3. Personal Care Products (PCPs)

- Categories : skin care, rinse-off, make-up, hair care
- Common chemical ingredients
 - Preservative → phenoxyethanol
 - Fragrance allergens → limonene, linalool, citral, hexyl cinnamal, alpha-isomethyl ionone, butylphenyl methylpropional
- Some chemicals → potential endocrine disruption / estrogenic activity.
- Need proper label, testing, and regulation to protect consumers.

Principles : Toxicology, Cosmetic chemistry, Endocrine disruption, Chemical risk assessment

4. Hybrid Micellar Liquid Chromatography (HMLC)

- Green analytical technique → micellar mobile phase (surfactant) + low organic solvent → less waste, low toxicity.
- Used to detect commonly used pesticides in vegetables.
- Photodiode array detector (PDA) → detect across a spectrum of wavelengths → identify and quantify pesticides.
- Method validation → sensitivity (LOD, LOQ), precision, accuracy, linearity, recovery, etc.
- Most frequently found pesticide in samples → imidacloprid (ICP)
- Some samples had no detectable pesticide.

Principles : Green analytical chemistry, Chromatography (HPLC), UV-Vis detection, Method validation

Important Concepts / Formulas

- Heat transfer : $q = -KA \frac{dT}{dx}$ (Fourier's law)
- Arrhenius equation : $k = A e^{-\frac{E_a}{RT}}$
↑ T → ↑ reaction rate (affects chemo/radio)
- Thermal dose (CEM43°C) :
 $CEM43 = \int_0^t R^{43-T(t)} dt$, $R = 0.5$ ($T \geq 43^\circ C$)
→ used to evaluate hyperthermia effect
- Multivariate analysis → PCA, PLS, etc.
- Data fusion → improve SNR, reduce noise, more reliable prediction

Why Hyperthermia is useful ?

- ① Damages cancer cells directly
- ② Improves oxygenation in tumor
- ③ Increases drug uptake
- ④ Inhibits repair of radiation-induced DNA damage

1. Summary

Topic	Key take-home
Hyperthermia	Heat 40-45°C → enhance radio & chemo but control temperature is challenging
PAT	Real-time monitoring, MSMs, data fusion → quality + efficiency
PCPs	Preservatives, fragrances, possible toxins → need regulation
HMLC	Green method for pesticide analysis in vegetables.

* Always choose the answer that matches the scientific principle and evidence.

Think → Concept → Application → Answer