22CGP059
Product Design

Semester 2 2022/23 In-Person Exam paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Answer **THREE** questions in total.

Each question carries 25 marks.

Candidates should show full working for calculations and derivations.

Statement of Needs is provided on the final page.

1. A greyscale printing process involves the use of a lithographic ink, comprising pigment, natural oil, polymer resin and solvent, methylene chloride, which is carcinogenic and an inhalation hazard. The pigment is typically a colloidal carbon; the oil contains fatty acids with multiple double bonds which are cross-linked in the presence of oxygen to make the ink permanent. The solvent and resin affect the ink's rheology. The solvent also removes ink from selected regions of the plate, releasing fumes during the printing process; the same solvent is used to clean the presses, releasing more fumes.

   Various stakeholders have been interviewed to determine their needs for a pollution-free printing process. A summary of their responses is contained in the attached list (Q1: Needs), see final page.

   (a) Propose an additional stakeholder for the project and provide three more needs for that person. [5 marks]

   (b) Identify any contradictory or redundant needs and organise the needs statements into a structured list, based on the desired functional properties of the chemical product. [10 marks]

   (c) Rephrase, combine and interpret three of the three-star needs and provide a short justification for each of these selections. [5 marks]

   (d) A proposed solution is to find a solvent to replace methylene chloride. Describe the methods that could be used to identify a suitable replacement with the same solubility as methylene chloride. Formulate five other possible target metrics that would need to be achieved for the replacement solvent. [5 marks]

2. (a) Provide four products (three in one group) such as chemical, biochemical or biomedicine products. Choose one of them as the benchmark product. Compare the other two products and explain the advantages and disadvantages of these products. Note: Example of weed killer discussed in the module and the products in your course work cannot be used as an example for this question. [6 marks]

   (b) Now you are a member of a product development team, and the benchmark product mentioned above is a current product in your company, but you need to develop some new products to align the future strategy of the company. First, you need to figure out two new product ideas for improving the benchmark product and explain the advantages and disadvantages of these two new product ideas. [4 marks]

   (c) Explain three driving forces for new product developments, with product examples for each of the driving forces. Identify the driving forces of your two new product ideas you proposed in (b). [6 marks]

   (d) Now you need to use a proper method to compare these two new ideas and identify the best idea. You need to explain your method and provide sufficient details of your method. [9 marks]

3. (a) Compare the differences and links between the chemical process and the chemical product design process and discuss using the chemical product: weed killer, as an example. [5 marks]

(b) In order to describe the right specifications of chemical products, calculations are commonly used to compare different chemical products and guide their design. The Cross equation is:

$$\mu_a = \mu_\infty + \frac{\mu_0 - \mu_\infty}{1 + \alpha\left(\dot{\gamma}\right)^n}$$

(i) Briefly explain the meaning of each symbol. What is the theoretical background of the equation? [5 marks]

(ii) Describe under what circumstances a Cross equation fluid apparently displays (i) power law, and (ii) yield stress behaviour. [5 marks]

(iii) Explain why concentrated emulsions show shear thinning behaviour. Can this be related to the theory behind the Cross model? [5 marks]

(iv) What unique feature of emulsions do you consider to be of most interest to designers of chemical products? Justify your answer. [5 marks]

4. (a) (i) Discuss how industrial companies apply different levels of innovation and adaptation to the development of new chemical products. [3 marks]

(ii) Provide examples of such companies (two examples for each level of innovation and adaptation) and describe how the development approach affects their product portfolios. [6 marks]

(iii) Describe the three methods of building and organising product development teams in these companies. Point out the advantages and disadvantages of different organisational structures. [6 marks]

(b) (i) Dementia is an umbrella term used to describe a range of progressive neurological disorders, that is, conditions affecting the brain. There are over 200 subtypes of dementia, but the five most common are: Alzheimer's disease, vascular dementia, dementia with Lewy bodies, frontotemporal dementia and mixed dementia. Some people may have a combination of different types of dementia and these are commonly called mixed dementia. Recommend and elucidate the possible healthcare products for dementia, evaluate the elements that might influence the design of these healthcare product(s). [3 marks]

(ii) Given their attractive pharmacological profile and intrinsic properties, peptides represent an excellent starting point for the design of novel therapeutics and their specificity has been seen to translate into excellent safety, tolerability, and efficacy profiles in humans. Compare and contrast the liquid and solid phase methods for peptide synthesis; assess their feasibilities for small- and large-scale manufacturing of peptides as biopharmaceuticals. [7 marks]

END OF PAPER

H Yang,
T Sun

Q1: Needs for a printing process with reduced solvent emissions

Lithographic press operator

O1	The ink spreads really easily over the lithographic plate surface.
O2	The ink doesn't half stink, so it's not much fun cleaning up afterwards.
O3	We have to wear protective gloves to do the cleaning. Sometimes I forget.
O4	The ink has a runny consistency so that it's easy to handle. Not too thin though.
O5	Charging the ink onto the presses needs to be done carefully and it takes a long time.
O6	It's a dirty job.
O7	I've been talking to our shop steward about improving the working conditions.
O8	We need to wash our hands to protect yourself from illnesses at a break.
O9	Typically, print runs last a few hours and then we have to clean the presses at the end of each shift.
O10	People don't do this job for very long.
O11	We've tried other inks, but some seem to stick to the litho plates and are hard to remove.
O12	I need a holiday.

Press manager

M1	The ink is expensive and we leave too much excess on the presses
M2	I'm worried that we'll be prosecuted for having volatile organics in the atmosphere.
M3	The cleaning process produces a lot of chemical waste, which is expensive to dispose of.
M4	Waste ink is also a problem for disposal, but there isn't too much of that.
M5	We've tried some alternative formulations, but they gave poor print quality.
M6	I've heard about water soluble inks.
M7	We always buy our inks from a local supplier.
M8	We haven't changed the materials since I've been here.
M9	New presses are very expensive and there's a long pay back time.

Customer

C1	We need a rapid turnaround on any jobs we submit for printing.
C2	High and consistent print quality is required.
C3	If the costs go up, we'll find an alternative printer.
C4	We've sent back some sales brochures, because they were printed in the wrong colours.
C5	We read newspapers every day during our breakfast.

Scientific consultant

S1	We need to control the surfactant properties of the ink to give high quality products.
S2	We've always chosen an ink formulation with an organic solvent.
S3	The pigment size distribution and morphology are critical.
S4	My daughter's just gone to Loughborough to do Chemical Engineering.
S5	The solvent reduces the ink viscosity which makes it easier to distribute on the litho plates.
S6	The solvent isn't expensive, but we use quite a lot for cleaning purposes.
S7	The expensive part is getting rid of the waste.
S8	I've never talked to anyone on the shop floor.

You should use the reference numbers given above to identify the needs statements in your answers.