Technical Report Questionnaire example answers

Contents

Part O – Underpinning Chemical and Bio Science		
0.1	Evidence of knowledge and understanding of: ▪ relevant aspects of chemistry and bioscience, to enable the understanding of chemical engineering principles.	Example 1 (Industry): Achieved grade A at A level in both Chemistry and Biology. During first year at university completed a module in Chemistry covering both organic and physical chemistry [XX%]. Laboratory work included organic synthesis, and analysis techniques including titration, Gas Spectrometry, Mass Spectrometry, and Chromatography. Example 2 (Academia): I completed my first degree in Mechanical Engineering from the University of xxxxx. Prior to this I obtained A-levels in Mathematics, Physics and Chemistry, achieving grades of A,B,B. This gave me a good basic understanding of all areas of chemistry: organic; inorganic and physical chemistry. I also completed a module in Materials Science (GENG1033) in my first year of study, which gave me further understanding of chemistry applied to a range of materials including polymers. The course book for this module was "Materials Science" by Richard D. Alexander (4^{th} Ed.). In my career with ABC Chemicals I have carried out a development project which looked at alternative formulations for the manufacture of chemical RST. This required obtaining a further understanding of chemistry and thermodynamics of the process to identify a different formulation and route for the production. I did this through study of standard textbooks (eg Denbigh, "The Principles of Chemical Equilibrium") and guidance from colleagues. I carried out calculations for the new formulation and I was also required to determine rate equations and heats of reaction, required for the process design.

Part A – Fundamentals of Chemical Engineering

1.1. Chemical Engineering Fundamentals

1.1.1	Evidence of ability to apply: ▪ the principles of material and energy balances.	Example 1 (Industry): To estimate the heat and material balance (H&MB) and performance for a licensed amine process, I developed a spreadsheet heat and material balance model. The licensor was unable to provide a H&MB in the required timeframe for the project which is why this work was needed. To achieve this, I determined the fundamental physical and thermal properties of the solvent based on the available information. I used this together with the selectivity of the solvent for CO2 and H2S that I had back-calculated to estimate the amine flowrate required under new conditions. To establish reboiler loads I used a combination of regressed data and semi-theoretical methods. The process flowscheme included pumps, heat exchangers, flashes, and absorber and stripper columns. Flashes were calculated within the spreadsheet by considering partial pressures and vapour pressures of the components. The model, including the estimated utility requirements for reboiler, condenser and plump loads was subsequently verified by the licensor confirming my approach and methodology. Through this task I learnt that it is relatively straightforward to approximate H&MB performance through use of chemical engineering fundamentals, even if specific details of the process are not known. I have since used this approach to rapidly derive process performance and provide simplified H&MBs to estimate equipment sizes without needing to resort to setting up complex simulation models. Example 2 (Academia): In my degree of mechanical engineering I have studied modules in Engineering Thermodynamics (GENG1053) and Heat Transfer (GENG2012), both at basic and advanced levels.

		In my work I have gained experience in this area through two projects. In the first case a new route for the production of chemical RST was sought. This was a batch process and it was necessary to find heats of reaction and rate equations in order to facilitate the design. I determined these through experiment and calculation and then was able to carry out a heat balance that tracked the reaction through time and, hence, determine the optimal cooling system required for the process. Later it was decided that a study should be carried out to convert from a batch to a continuous process. I was part of a small team of 3 that determined a possible flowsheet. I was then responsible for carrying out the mass and heat balances on the system and to look at a number of scenarios, including recycle rates, to determine the optimal process configuration.
1.1.2	Evidence of understanding of: ▪ the principles of momentum, heat and mass transfer and application to problems involving flowing fluids and multiple phases.	Example 1 (Academia): During my degree in Mechanical Engineering, I have studied modules in Engineering Thermodynamics (GENG1053) and Heat Transfer (GENG2012) at both basic and advanced level. I have also completed a module in Fluid Mechanics (MENG2032), covering flowing fluids in different scenarios. At a more advanced level I completed a module in CFD (Computational Fluid Dynamics, MENG4009) and applied this to a small project as part of the module assessment.
1.1.3	Evidence of understanding of: ▪ the principles of equilibrium and chemical thermodynamics, and application to phase behaviour, to systems with chemical reaction and to processes with heat and work transfer.	Example 1 (Industry): I prepared an Aspen Plus simulation for a Hydrogen plant using Steam Methane Reforming technology (SMR) and Natural Gas as feedstock. This included a lot of background reading such as "Modelling of Chemical Kinetics and Reactor Design": Selecting the appropriate thermodynamic packages (i.e. Equations of state) for the different sections of the plant (considering the presence or not of water). I ensured that there was a suitably designed heater at the inlet to the plant to prevent liquid drop-out when the pressure of the natural gas feed was reduced from the pipeline (as a result of the JT effect). For the reformer and the Shift Reactors, I included the relevant chemical equations and provided the expected approach temperatures to equilibrium based on Catalyst vendor feedback and corporate

		experience. I prepared different simulations with different reactor temperatures and steam:carbon ratios to optimise the design parameters. The simulation model included a Hydrogen Compressor to meet export pressure requirements. For the compressor I double checked the simulation results through hand calculations to validate the results for power consumption. From this work I gained a good understanding of the trade-offs while optimising SMR process parameters and effects of temperature and catalyst selection on the chemical equilibrium and undesirable side reactions. I used these learnings to develop a training manual and course for the Hydrogen plan team to help new members get up the learning curve and to use as a reference resource that could be further developed and expanded. Example 2 (Academia): My understanding of this area comes from two sources. Firstly, through my A-level and degree studies in modules covering thermodynamics, heat transfer and material science. I have also applied these principles in my work experience in a project to determine a new route for the production of chemical RST. This was a batch process and it was necessary to find heats of reaction and rate equations in order to facilitate the design. I determined these through experiment and calculation and then was able to carry out a heat balance that tracked the reaction through time and, hence, determine the optimal cooling system required for the process. During this study it was also necessary to consider phase changes during the process and the effect on equilibrium under different conditions of temperature and pressure.
1.1.4	Evidence of understanding of: ▪ the principles of chemical and/or biochemical reaction and reactor engineering.	Example 1 (Academia): My understanding of this area comes from my A-level studies in chemistry, as a basis, and the module in my degree in materials science. I also had to determine rate equations and apply to the design of a batch process, and, following the successful completion of this, to determining a possible route as a continuous process, which required further calculation of reactor size and configuration using the determined reaction kinetics.

1.2. Core Chemical Engineering – Mathematical Modelling and Quantitative Methods		
1.2.1	Evidence of: ▪ ability to apply, a range of appropriate tools such as dimensional analysis and mathematical modelling.	Example 1 (Industry): A number of plant closures across the site had resulted in a reduction in the utilisation of a number of cooling towers. It was proposed to transfer the cooling water supply for one of the chemical plants from one cooling tower to another: this would enable the other cooling towers to be shut down and decommissioned, providing a saving on fixed and variable costs. I was the responsible process engineer for this project. I produced a flow network model using the ABB PEL suite of process engineering programs. My inputs to the model included pipe sizes and lengths, flow requirements and pump performance data. I built in heat exchanger pressure drops to the model by using curve fitted data from polynomial regression. I used the model to simulate the performance of the cooling water network and to assess the impact of the proposed process changes. I verified the model results by performing on site checks using a portable ultrasonic flow meter and pressure gauges. These checks were also used to assess the performance of the cooling tower pumps versus their respective pump curves. I then adjusted the model to reflect my findings from the actual plant conditions. The simulation results generated by the final model provided evidence that the single cooling tower had sufficient capacity in terms of flow and pressure to support the additional chemical plant.
1.2.2	Evidence of: ▪ knowledge of the role of empirical correlation and other approximate methods and ability to apply these to engineering problems.	Example 1 (Industry): I currently work for the Site Services technical team on site; the responsibilities of the team include providing technical support to the operational staff as well as producing process designs for a number of projects across the various utility systems. When assessing the technical and financial feasibility of a project, it is often necessary to produce a

		± 40 % cost estimate for the project. As part of this, it is necessary to perform high level calculations in order to estimate equipment sizes to get an appreciation of the potential cost. As part of this, I use various chemical engineering rules of thumb such as assuming an overall heat transfer coefficient in order to estimate a heat exchanger area, or assuming an economical velocity for sizing liquid or gas pipelines. When estimating the cost of equipment, I use a range of cost estimating methods such as the six-tenths rule or equipment cost correlations. For estimating the installed cost of a project, I have used the detailed factorial method to get a total cost and then and sanity check the numbers against an overall Lang factor versus Main Plant Item (MPI) cost.
1.2.3	Evidence of: ▪ competency in the use of numerical and computer methods, including commercial software, for solving chemical engineering problems (detailed knowledge of computer coding is not required).	Example 1 (Industry): I am proficient in the use of process simulation software such as Aspen Plus, Hysys, and ProII simulation software. Simulations I have prepared include Hydrogen plants (Aspen), and Gas-to-liquid plants (Hysys and ProII). These have been used as the process design basis for projects in FEED (Front End Engineering Design). Other computer methods include the use of corporate excel based spreadsheets for pipework pressure drop calculations, PSV sizing, vessel design, compressor and pump power calculations. My learnings from use of these programs is the importance of cross checking the results either with similar projects to benchmark the results (in terms of process equipment sizing), and for simulations performing manual checks to ensure proper convergence and, in particular, that mass is not lost in recycle loops (e.g. perform overall facility & unit manual material balances). I developed a spreadsheet for checking orifice plate pressure drop calculations to verify plant test data since the actual meter reading was suspect. This resulted in calculating a different flowrate from that reported by the control system, through using the raw pressure drop data from the instrument with the known orifice characteristics. As a result, I checked the calculation in the control system and found it to be in error. The learning from this was that the information provided by the control system cannot always

		be relied upon and that where possible raw data should be obtained when undertaking plant tests to enable investigation of anomalous results. Example 2 (Industry): I was asked to review the existing design of the relief on the 75 barg ethylene distribution system on site. The relief stream is required to protect the pipework against block in thermal expansion. Due to the operating conditions of the pipeline, the ethylene is in the supercritical phase and therefore requires a suitable methodology for determining the required relief rate and orifice area. Through my research I determined that the commonly accepted methodology for sizing supercritical reliefs is the one presented in "Rigorously Size Relief Valves for Supercritical Fluids" by Ryan Ouderkirk. This method requires physical property data over a range of conditions as well as the solution of the isentropic nozzle mass flux equation for a number of time steps. As a result, this calculation is very laborious and time consuming to perform by hand. Instead, I conducted research into potential software that could be used to perform the same calculations. I found that there is an in-built tool in Aspen HYSYS for sizing safety relief devices; this tool uses the exact same methodology described by Ryan Ouderkirk for sizing supercritical reliefs. I had to select a suitable fluid properties package in order to obtain accurate physical properties data for the simulation. I used the safety valve sizing tool and configured the model to select the appropriate methodology and parameters to perform the calculation. I verified the results completing sample manual calculations.
1.3. Core Chemical Engineering – Process and Product Technology		
1.3.1		Examples coming soon
1.3.2		Examples coming soon

1.3.3		Examples coming soon

1.4. Core Chemical Engineering – Systems		
1.4.1	Evidence of understanding of: ▪ the principles of batch and continuous operation and criteria for process selection.	Example 1 (Academia): I am involved in the teaching of batch and continuous operations in a second year module to undergraduate students based on my previous experience during my PhD. My doctoral research work involved selecting appropriate materials of construction for pilot-scale fermentation reactions and required control systems to maintain temperature, pH, flow and pressure. For this I read many research publications and also textbooks on bioreactor technology, including "Biochemical Engineering" by Blanch & Clark. The research was part-funded by an industrial company and required me to give a number of presentations to the company which advised them on the approach needed for commercial scale-up. My teaching covers various forms of batch and continuous operations including mixing, reactions and separation. As a recipient of a recent teaching fellowship, I have been able to extend my knowledge and understanding in operations and practice through a 2-month secondment to the local refinery and work-shadowing professional engineers. My contribution was noted through the successful implementation of a major plant modification to a distillation column to adjust new feedstock compositions to meet defined product specifications.

1.4.2	Evidence of understanding of: ▪ the inter-dependence of elements of a complex system and ability to synthesise a conceptual process by combining steps into a sequence and applying analysis techniques such as balances (mass, energy) and pinch.	Example 1 (Academia): Prior to my current position as an academic, I was involved in a 12-month placement with a local waste treatment company. This involved advising the company on the installation of a new novel batch alkali digester which used NaOH and KOH to digest protein-based waste from a local abattoir to eliminate harmful prion proteins. It was my responsibility to complete an audit of the anaerobic digester which was installed on site. This involved carrying out mass and energy balances to determine the required levels of materials needed and caustic required. As a novel process, I was also responsible for the technical evaluation of the process which led to the preparation of an operators' manual for the safe and effective operation of the process. The output from the digester formed the feed to another part of the overall or integrated waste treatment. I worked directly with the shift managers on site to advise them of operations.
1.4.3	Evidence of ability to: ▪ determine the dynamic response to changes in a process, and ability to design measurement and control functions and determine their performance.	Example 1 (Industry): I performed a Dynamic process control study for a compression system considering a range of process upset conditions including sudden opening/closing of inlet and outlet valves and increased suction pressures to the unit. This was to determine how the pressures within the system would develop considering a range of different scenarios and if the currently installed relief valves were sized sufficiently to handle the load. This was required due to a recent upgrade of the compressors internals that changed the compressor curve. The model included incorporating all the control system functions around the compressor and adjoining process. The result of this study included recommended changes to trip set points and the results used as input to a LOPA (Layers of Protection Analysis). Example 2 (Academia): As a lecturer, I have responsibility for delivering a practical class which is based on a live demonstration process. This involves a laboratory demonstration control room linked a distillation column that separates methanol from water. I supervise groups of four students at a time in the control room which comprises

		four screens depicting the flowsheet and control system with alarms, and linked to the continuously fed distillation column in the laboratory outside. Students gain an appreciation of the live operation and can visually appreciate the impact of their decisions to make appropriate adjustments to the set points. We use the textbook by Pollard "Process Control" as the basis for the course. My class is structured around encouraging the students to appreciate and understand the effect of process disturbances and the ability to control them. As examples, I create step changes in flow to the column or ramped decreases in condenser temperature which affect the behaviour of the column. This is a form of simulation typically encountered in practice. The students are required to present their work as a group at the end of the practical session with me that links theory to practice. I recently received a teaching award for my innovation in teaching based on this.

1.5. Core Chemical Engineering – Process Safety		
1.5.1	Evidence of: ▪ ability to identify the principal hazard sources in chemical and related processes (including biological hazards); ▪ knowledge of the principles of safety and loss prevention and their application for inherently safe design; ▪ knowledge of the principles of risk assessment and of safety management, and ability to apply techniques for the assessment and abatement of process and product hazards; ▪ ability to apply systematic methods for identifying process hazards (eg HAZOP) and for assessing the range of consequences (eg impact on people, environment, reputation, financial).	Example 1 (Industry): For the XYZ project I performed a HAZID and Process Safety Review based on the Process Flow Diagrams and material balances available. As the project matured, I was the process engineer in the HAZOP for the project and was responsible for closing out actions. In addition to these reviews, I prepared the process information required for, and participated in the Area Classification reviews. I led a review of the ABC facilities to assess the risks and compliance against corporate process safety requirements. This included assessing risks against common process safety hazards highlighted in major accidents within the process industries. These included safe siting of portable buildings, overfilling of Tanks, liquid release from vents, exposure to Low Temperatures (embrittlement), Alarm Management, Toxic Gas, amongst others. Following the review, I compiled a report with findings and proposed actions to address the gaps identified. Example 2 (Academia): My knowledge in this area comes mainly from my industrial experience. However, during my degree I carried out extensive laboratory work and was instructed on and had to abide by the safety regulations of the laboratory, including procedures and protective clothing. There was a hazard assessment for all my laboratory experiments and for my final year research project I had to write the hazard assessment for my project in association with my supervisor. In my industrial experience I have carried out some laboratory work and been involved in process development and this has required a full understanding of the hazards associated with chemicals and related processes. How to handle the chemicals from receipt to use and any special precautions that need to be taken. All to be embedded in a comprehensive hazard and risk assessment.

		I have been involved with process design and modifications for both batch and continuous processes. I have worked alongside experienced chemical engineers and learned and applied the principles of inherent safety. For example, in one of my earlier projects we were looking for a different product route in order to reduce the risk from the chemicals used as raw materials. I have been involved in risk assessments and safety audits on existing chemical processes. I have attended HAZOP sessions related to the projects I have worked on. I have attended the following training programmes given below: XXXXX HAZOP XXXXX Safe handling and disposal of chemicals XXXXX Safety in the workplace

1.6. Core Chemical Engineering – Sustainability and Economics		
1.6.1	Evidence of understanding of: ▪ the principles of sustainability (environmental, social and economic) and ability to apply techniques for analysing the interaction of process, product and plant with the environment and minimising adverse impacts.	Example 1 (Industry): I conducted a noise survey around the fenceline of a new facility to ensure that the noise levels were within the design limits. For the XYZ project, I provided emission data to the environmental team to model the dispersion from a fired heater stack to ensure that the design met the environmental standards for the project.
1.6.2	Evidence of ability to: ▪ apply the principles of process, plant and project economics.	Example 1 (Industry): For a several different concepts for an offshore oil project I prepared cost estimates using the corporate software tool, estimated operating costs and used the oil production profiles as inputs for the economic model. I then used a spreadsheet model to assess the Net Present Value (NPV), Internal Rate of Return (IRR) and Value to Investment Ratio (VIR) for each concept. Using this data, I was able to propose the optimal economic concept for the project.

2. Chemical Engineering Practice		
2.1	Evidence of: ▪ knowledge and understanding of laboratory (or larger scale) practice, and ability to operate bench- (or larger) scale chemical engineering equipment.	Example 1 (Industry): As part of the Chemical Engineering Laboratory work at university I undertook an experiment to look at pressure drop in fluidised beds for various flowrates. This included the use of bench scale fluidised bed apparatus. I was awarded 18/20 for my work, analysis and report. During the commissioning of an Air Separation Unit I was responsible for operating the cryogenic Argon system. This system (included distillation column) was very sensitive to upsets within the rest of the plant and as a result required careful manual operational intervention during start-up/initial operation to maintain stability until the control loops were correctly tuned.
2.2	Evidence of: ▪ ability to undertake well-planned experimental or plant work and to interpret, analyse and report on experimental or plant data.	Example 1 (Industry): I prepared a Plant test procedure for an Amine plant to remove H_2S and CO_2 from Natural Gas. This included careful review of the P&IDs to assess and document the required instrumentation readings to be taken, and where necessary temporary instrumentation to be installed. I led the Performance test, ensuring that prior to testing all instruments were properly calibrated. The test included a Gamma Scan of the Absorber and Regenerator columns to establish liquid loadings on distributor trays and packing to identify when the columns were entering flooding. After the test, I analysed the data using spreadsheet models and prepared a report. An outcome from the test was that I identified the columns were flooding at lower levels than design (requiring further investigation) and that one of the flowmeters in the Control System readout had been improperly labelled as it was reporting Am^3/h rather than Sm^3/h.

2.3	Evidence of: ▪ ability to find and apply, with judgement, information from technical literature and other sources.	Example 1 (Industry): I wrote a guideline on Gas Plant design including descriptions on the different technologies that can be applied for different functional requirements. This included inlet facilities (slug catchers, etc), Acid Gas Removal, Dehydration, Mercury Removal, Hydrocarbon Dew-pointing, fractionation, liquid treating and compression. This required me to research standard texts (GPSA manual, Campbell, etc), perform literature searches (Oil and Gas Journal, Hydrocarbon processing, etc), Vendor/Licensor literature as well as in-house data. The guideline included several metrics including process performance and cost estimates which required critical assessment of the available information to ensure that data from the various sources were assessed on a comparable basis.
2.4	Evidence of knowledge and understanding of: ▪ materials science and its application to the selection of materials of construction, corrosion protection etc.	Example 1 (Industry): As part of my university degree the course included modules on materials of containment, focussing on the correct selection of materials for different applications considering the fluid type and process conditions. This included assessment on corrosion and failure mechanisms (such as stress corrosion cracking, Hydrogen embrittlement, work hardening, etc). As the responsible process engineer for an Amine unit (to remove CO_2 and H_2S) I worked with the project Metallurgist to develop the Material Selection Diagrams and Material Selection report for the project. Due to moderate temperatures and the risk of chlorides within the process (carried over from formation water), alternatives to stainless steels (super duplex or titanium) were used in parts of the plant subject to corrosion from wet CO_2/H_2S to design out or reduce the risk of chloride stress corrosion cracking.

2.5	Evidence of a basic understanding of: ▪ relevant elements from engineering disciplines commonly associated with chemical engineering, such as electrical power and motors; microelectronics; mechanics of pressure vessels; structural mechanics.	Example 1 (Industry): My university degree included modules on Materials (including mechanical design), and Civil Engineering within the first year [X% and Y% respectively]. During my graduate development I had a placement in the mechanical design group where I prepared standard spreadsheets for the design of pressure vessels and supporting structures. I was also able to witness the manufacturing and testing of these vessels within our fabrication facility. In understanding the implications of adding electrical equipment (for compressors, pumps, etc) to existing process plant, I have gained an understanding of basic electrical engineering concepts and how to read single line diagrams.

3. Chemical Engineering Design and Design Practice		
3.1	Evidence of: ▪ understanding of the importance of identifying the objectives and context of the design in terms of: business	Example 1 (Industry): A change in raw material produced a reduced rate of reaction, leading to production rate decreases and an increased risk of unreacted material being vented to atmosphere. Following successful lab trials by others utilising Compound X (CX) oxidising agent added to the new raw material, I was asked to be the

	requirements; technical requirements; sustainable development; safety, health and environmental issues; appreciation of public perception and concerns.	process design engineer for a system to install an automated dosing system on plant for 4x batch reactors. I estimated the annual volume and purchase cost of CX vs the cost of lost production (OPEX) which helped justify the proposed project's business case. I also produced calculations showing the predicted reduction in emissions to atmosphere to be used in the business case. I obtained preliminary costs of new equipment to assist in collating early order of cost CAPEX estimates. I was the process engineering representative in the subsequent HAZOPS and Management of Change reviews, and assisted in LOPA study. I provided the Site Safety Manager with MSDS information on Compound X and on the proposed storage quantities to assist in notification to HSE regarding Hazardous Substances Consent.
3.2	Evidence of: ▪ understanding of design as an open-ended process, lacking a pre-determined solution, which requires: synthesis, innovation and creativity; choices on the basis of incomplete and contradictory information; decision making; working with constraints and multiple objectives; justification of choices and decisions taken.	Example 1 (Industry): I liaised with other production sites in my company and identified that another location already used a similar oxidising agent to CX, Compound Y (CY). I arranged a site visit to see how they handled the receipt of the CY, arranged its storage and its transfer to plant. I then saw how they dosed CY into the plant process, and how it was automated. I built this learning into my Process Flow Diagram (PFD) development. I used CX manufacturer's MSDS to determine the appropriate materials of construction, and importantly, what materials to avoid, in the system design. I also discovered that CX, unlike CY, needs to be kept above 15°C to remain liquid, and so identified that the storage vessel, pumping equipment, pipework and valves would need to be heat traced to stop CX solidifying between batch dosing. In talking to more experienced engineers from other disciplines, I discovered electric tracing was preferable to steam as (i) temperature can be controlled (ii) steam needs condensate systems and is prone to leaks (iii) electric is cheaper to install and maintain. I also determined that thermal relief would be needed for CX for blocked-in sections. I included all of these requirements in the P&ID I produced from the original PFD.

3.3	Evidence of: ▪ ability to deploy chemical engineering knowledge, using rigorous calculation and results analysis, to develop a design and with appropriate checks on its feasibility and realisability.	Example 1 (Industry): I calculated the daily use of CX, clarified the quantities and frequency of supplies from manufacturer and non-delivery durations (eg weekends, national holidays) in order to determine the minimum storage inventory required. I then contacted suppliers of bespoke storage units to determine they could provide a large storage cabinet meeting requirements, eg capacity, temperature controlled, alarms if temperature too high/low, integral bund, lockable, suitable for outdoor use etc. I produced process data sheets for dosing pumps based on dosing duration and pressure drop across the systems, and for the local storage vessel. I provided data sheets for level, temperature and pressure instruments and alarms. I also calculated the size of thermal reliefs and for the relief lid on the storage vessel. Once preliminary piping arrangements were available, I calculated the lengths and volumes of pipework, which enabled me to calculate the heat input needed from the electric tracing. All calculations were checked by the senior process engineer.
3.4	Evidence of: ▪ ability to take a systems approach to design appreciating: complexity; interaction; integration.	Example 1 (Industry): I worked with the AutoCAD designer to ensure that my preliminary hand-drawn P&ID was transferred correctly to AutoCAD. This was then updated as the design developed and detail added; I checked it before each revision was issued. This included such things as ensuring that the correct instrument labels were shown, correct types of valves were shown, requirements for no lutes included, actions from HAZOPs were included. I reviewed the preliminary equipment layout and pipework design with the mechanical project engineer to ensure that they met process design intent, such as no lutes, manual valves were in accessible locations, reliefs were directed to safe locations, pumps were located in adequately sized bunds.

		I worked with the E&I engineer to determine the Area Classification (zoning) requirements due to CX and the impact on electrical equipment, eg pump motors, instruments. We also worked together to ensure that they understood my instrument and trace heating data sheets so that the correct items could be specified and procured. I specified the initial control philosophy to achieve automated dosing, which determined how many valves had to be automated, where an operator would need to make manual interventions etc. I then worked with the software engineer who was to update the DCS configuration to check that the operating requirements would be met. I was then part of the software testing team.

Part B – Advanced Chemical Engineering

4.1. Advanced Chemical Engineering Depth		
4.1	Candidates should provide evidence of attainment of advanced chemical engineering Depth according to the criteria listed above in at least 1 of the subjects below: ▪ chemical engineering fundamentals (thermodynamics, fluid flow, chemical/biochemical reactors, etc) ▪ modelling and quantitative methods	Example 1 (Industry): Having completed both in-house and external training on specialised design software, I joined the company's design team. The team has responsibility for the design of new production units as well as reconditioning existing units to meet regulatory compliance in terms of quality assurance and emissions. The team comprises six professional engineers including four chartered engineers and headed by a chartered mechanical engineer. With personal responsibilities within the team for the chemical flowsheeting including detailed mass and energy balances, I use my knowledge of thermodynamics as well as the chemical reactor kinetics and specialist texts such as "Process Flowsheeting" by A. W. Westerberg. This is often challenging as detailed data is unavailable which requires innovative approaches to solve problems. This ranges from using advanced models from the latest published literature to complex statistical extrapolation techniques. Increasingly, the modelling uses sophisticated

	▪ process and product technology (processes and process equipment design and performance) ▪ chemical engineering systems (batch/continuous, integration, control, dynamics etc) ▪ process safety ▪ sustainability and process economics	software modelling of solid-solid interactions at the molecular interface, which is based on sophisticated thermodynamics models. I am also responsible to testing and validating the data with the design. Example 2 (Academia): As an early career academic, I have responsibility for the delivery of three modules in Chemical Thermodynamics (ChE6002), Advanced Fluid Dynamics (ChE6005) and Advanced Chemical Reaction Engineering (ChE4012) on the Advanced Chemical Engineering master's programme. This involves lectures, tutorials and practical classes covering advanced computational modelling techniques as well as novel reactor design applied to the oil, gas and nuclear industries. I am responsible for the module leadership of two of the modules which involves curriculum development and working with senior colleagues who also contribute to the module. As such I have had to attain all of the relevant knowledge and understanding associated with these modules, which are all rated as advanced chemical engineering depth. I am also responsible for introducing innovations in teaching which includes using a flipped classroom approach as well as developing an online virtual laboratory. I also engage with the Department's Industrial Advisory Board and use invited industrials to present real-life applications particularly in terms of chemical reactor operation. I have supplemented my own experience with two periods of one week shadowing professional engineers at the local refinery. This has enabled me to teach effectively both theory and practice to undergraduate students.

4.2. Advanced Chemical Engineering Breadth		
4.2.1	Candidates should provide evidence of attainment of advanced understanding of chemical engineering in its broadest sense according to the criteria listed above.	Example 1 (Industry): I have wider responsibility within the company for the management of effluent monitoring and auditing. This is an essential and legal requirement of the company to ensure that it meets regulatory compliance. As the lead in a team of four, and as the only engineer, I have responsibility for ensuring the data is

available and reliable, and making recommendations to advise the company on how to meet compliance where necessary. This involves analysing considerable amounts of complex data that includes flows, temperatures and concentrations of solids, liquids, vapours and gases. A data visualisation approach is used to identify where there are concerns which requires competences in advanced statistical modelling for which I have used "Understanding Advanced Statistical Methods" by Westfall and Henning as well as other books and courses. I also have a firm understanding to regulatory procedures applied to waste treatment, associated environmental pollution abatement systems as well as the law associated with corporate responsibility. I have received regular external training by the regulator and recently completed a module on regulatory compliance passing with distinction. My work is currently overseen by a chartered engineer and I report my work every quarter to the company's Board.

Example 2 (Academia):

I have responsibility within the Faculty of Engineering for the delivery of a postgraduate master's module in Process Systems Modelling (ChE6015). This is delivered to students from a wide range of engineering backgrounds and includes chemical engineers as well as other engineering disciplines. The module is presented in the form of workshops and presentations covering approaches to process systems applied across a wide range of industries. It requires a good working knowledge of mathematics and involves computational modelling techniques applied to real data. As the lead for the module, I have been responsible for curriculum development and assessment, for which I have adopted a new textbook "Modelling and Simulation of Chemical Process Systems" by Nayef Ghasem. Module development has also involved working with industrialists as well as fellow engineers across the faculty to incorporate a wide range of examples and applications. These include applications of predictive information for decision support in process innovation, design and operation with the aim of creating faster and safer decisions by reducing uncertainty from more traditional process simulations. One such example is the approach used to optimise and improve the process economics of a complex multi-tubular catalytic reactors recently installed at the local refinery. Using my contacts with the local IChemE Subject Group, I arrange for site visits to the refinery for the students to gain an appreciation of both the problem and solution in practice.

4.3. Advanced Chemical Engineering Practice		
4.3.1	Evidence of: ▪ awareness of research and developments in relevant technologies and their potential impact on current practice and its limitations. ▪ having undertaken research and/or development project work that provides opportunities for: application of research methods; originality and experience in dealing with uncertainty and new concepts and/or applications. ▪ having communicated the outcomes of the project work in a professional manner that may include: thesis; publication; poster; presentation.	Example 1 (Industry): On joining the company after graduating four years ago, I been actively involved in working on prospective and future pipeline projects. These are intended to replace existing pipelines which supply feed materials and products to storage with advanced control measurement systems. My responsibility has been the design and development of these control systems and includes procurement, installation and commissioning with a team of technicians. This has involved identifying and implementing the latest design of control system which can be operated remotely and in harsh environment conditions across a range of flow conditions capable of handling toxic materials. To achieve this, I have formed a close relationship with academics from the faculty of engineering at the local university to assist me with the research and development, and includes supporting postgraduate students specialising in control engineering. This has included contributing to research seminars on a regular basis and well as supporting student placements within the company for which I am the industrial supervisor. I have access to databases such as Scopus, from which I download and read the latest research articles. Example 2 (Academia): I joined the University as a lecturer after completing my postdoctorate. I have continued to develop my experimental laboratory research as an independent researcher. I have extended my specialist area into advanced and novel reactor simulation and design, and, in particular, biochemical reactor development. I have obtained both internal and external funding to establish equipment and funding for two PhD students and, to date, had one successful completion from an industry-funded studentship. I am also supported by three MSc students and four final year MEng Chemical Engineering students. I have been responsible for the design and development of novel reactors and have supervised a team of workshop technicians to fabricate a range of novel pilot-scale bioreactors. This has required the application of advanced materials and also the use of the 3D printing which is available within the faculty. The output

		of the research group has been the publication of four research papers in four years in internationally recognised journals. I have also presented my research work at two international research conferences which has led to attracting a number of international partners interested in developing this work. This has included being invited to join an international Horizon2020 application led by leading researchers at a French institution.

4.4 Advanced Chemical Engineering Design and Design Practice		
4.4.1	Evidence of: ▪ ability to work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies.	Example 1 (Industry): I have been responsible for the design of a number of specialist unit operations which have been built and successfully operated within the company's manufacturing plant. This has included the design of a novel membrane bioreactor used to reduce the concentration of harmful substances produced in the effluence of the company's internal reprocessing unit. Working within a team of five process engineers, the design involved the sizing of process plant equipment based on the flowsheeting requirements of flows, temperature, pressures and concentrations. The complexity in the design was based on the unsteady state nature of the flows and the variability of the concentrations in the effluent. Within the team, it was my responsibility to model the process dynamics to predict the performance of the bioreactor. This involved computational modelling of the bioreactor under both steady state and dynamic conditions using available data and where incomplete, the use of predicted plant data from thermodynamic models. I was also responsibility for writing the operating instructions including start-up and shut-down procedures as well as maintenance manuals detailing how to replace the membrane filters. After the bioreactor was constructed and installed, I was seconded to the team responsible for
4.4.2	Evidence of: ▪ having achieved, within a design project(s) some of the 'Depth' and 'Breadth' (see above) Outcomes of	

	Advanced Chemical Engineering described in the preamble, eg: ▪ detailed design of control systems based on process dynamics; ▪ design and operation aspects of start-up and shut-down; ▪ design of a process for a novel product for which data are unreliable or limited; ▪ environmental impact and Life Cycle Analysis; ▪ evaluation of financial and other risks.	commissioning the unit to ensure that it was able to meet the specifications detailed in the Design Safety report. This involved using inactive materials prior to the unit being approved to go live. Example 2 (Academia): I am responsible for supervising chemical engineering Design Project groups in the final year of the MEng Chemical Engineering degree programme. This involves supervising and assessing two groups of five students each. Spanning 12 weeks this involves the complete design of a chemical process. The design project changes each year and is always topical, current and relevant. For example, the recent project concerns the design of a biodiesel production facility using waste cooking oils. It is my responsibility to define the scope of the project with a design brief for which the students are required to successfully complete the design that includes flowsheets, mass and energy balances as well as equipment design. It also includes process economics, SHE, ethics, sustainability, start-up and shut down procedures. I support the students with a steady state flowsheet simulation using Aspen HYSYS and PRO/II. In terms of the advanced chemical engineering aspects of design, the brief does not present a full set of data and students are required to use their initiative and skills to obtain missing data. I also supervise the students to complete dynamic control of a continuously operating chemical reactor subjected to simulated process interruptions. Students are required to apply their knowledge of advanced control theory to optimise the control. I use my network of contacts in industry through the local IChemE Members Group to meet with the students towards the end of their project. The project ends with the submission of the project and presentation to invited industrialists.
4.4.3	Evidence of: ▪ ability to apply and adapt design processes and methodologies in unfamiliar situations.	